

Section H. Appendices

H.1 Detailed Budget

H.1.1 Budget Summaries

Foldout H-1 shows the entire LISA budget in the required format (Excel tab Table 2). Tables H-1 through H-3 are summary breakouts of this information by project phase.

Table H-1: Technology Development Cost Funding Profile (FY Costs in Real Year Dollars (\$M). Totals in RY and FY03 Dollars)

Cost Element	Adv Tech Dev						SUBTOTAL	
	PY	FY03	FY04	FY05	FY06	FY07	Adv Tech Dev	
							RY\$	FY03\$
Start of ATD to Launch + 30 days (ATD, formulation and implementation)								
1.1 Management	0.6	0.3	0.4	2.0	2.9	0.1	6.3	6.0
1.9 Technology Development (excl. 1.9.4)	2.0	0.9	4.0	8.8	11.4	4.6	31.7	29.6
1.9.4 Systems Verification	1.2	1.2	1.4	3.7	3.3	3.3	14.1	13.2
Subtotal before Reserves	3.8	2.4	5.8	14.5	17.6	8.0	52.1	48.7
Reserves	0.0	0.5	0.8	3.7	12.6	11.0	28.7	26.1
Total ATD, formulation, and implementation through launch plus 30 days	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8
Total LISA (NASA) cost	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8
FULL COST OF:								
NASA FTEs		0.8	1.3	2.7	4.2	2.3	11.2	8.9
OSS Required Funding for LISA	3.8	2.2	5.3	15.5	26.1	16.7	69.6	65.9
CONTRIBUTIONS OUTSIDE OF UPN 785-30 US (NON-LISA) CONTRIBUTIONS								
Technology Flight Validation (NMP/ST-7)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8
Total US Cost (NASA)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8
ESA CONTRIBUTIONS								
1.1 Management	0.2	0.1	0.2	0.7	1.1	0.0	2.3	2.2
1.9 Technology Development	4.3	2.6	4.0	8.8	11.4	0.0	31.1	29.6
LISA Test Package	5.3	18.2	21.8	13.2	3.6	0.0	62.1	60.5
Technology Flight Validation (SMART-2)	7.0	9.0	15.5	17.9	13.2	0.0	62.5	60.0
Subtotal before Reserves	16.8	29.9	41.4	40.6	29.3	0.0	158.0	152.3
Reserves	0.0	9.5	13.2	13.9	11.1	0.0	47.7	45.5
Total ESA Cost	16.8	39.3	54.6	54.5	40.3	0.1	205.7	197.8
Combined Contributions	19.8	53.8	74.7	66.3	44.0	2.9	261.3	251.6
Total Mission Cost (All Sources)	23.6	56.8	81.3	84.4	74.2	21.9	342.1	326.4

Table H-2: Formulation Cost Funding Profile (FY costs in Real year Dollars (\$M). Totals in RY and Fixed Year '03 Dollars).

	Adv Tech Dev						SUBTOTAL Adv Tech Dev		ATD plus Formulation							SUBTOTAL ATD plus Formulation	
Cost Element	PY	FY03	FY04	FY05	FY06	FY07	RY\$	FY03\$	PY	FY03	FY04	FY05	FY06	FY07	RY\$	FY03\$	
Start of ATD to Launch + 30 days (ATD, formulation and implementation)																	
1.1 Management	0.6	0.3	0.4	2.0	2.9	0.1	6.3	6.0	1.0	0.6	1.6	4.3	6.7	6.1	20.4	18.9	
1.2 System Engineering/Integration Contractor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	1.5	3.6	7.5	7.7	21.2	19.4	
1.3 Mission Assurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.7	1.6	2.2	5.0	4.6	
1.4 Science (excloding 1.4.4)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.5	1.2	2.1	2.7	3.3	10.8	10.0	
1.4.4 Education & Public Outreach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.6	0.9	2.5	2.3	
1.5 Payload System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	1.3	2.7	7.7	9.8	23.1	21.1	
1.6 Flight System																	
1.6.2 ATLO (SE&I Contractor)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	3.8	6.2	5.5	
1.7 Mission Operations System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.8	2.2	1.9	2.7	8.6	8.0	
1.9 Technology Development (excl. 1.9.4)	2.0	0.9	4.0	8.8	11.4	4.6	31.7	29.6	2.0	0.9	4.0	8.8	11.4	4.6	31.7	29.6	
1.9.4 Systems Verification	1.2	1.2	1.4	3.7	3.3	3.3	14.1	13.2	1.2	1.2	1.4	3.7	3.3	3.3	14.1	13.2	
1.10 Mission Software	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.8	3.6	10.2	12.9	30.5	27.9	
Subtotal before Reserves	3.8	2.4	5.8	14.5	17.6	8.0	52.1	48.7	6.5	6.4	15.4	32.2	56.1	57.4	174.0	160.3	
Reserves	0.0	0.5	0.8	3.7	12.6	11.0	28.7	26.1	0.0	0.5	0.8	3.7	12.6	30.9	48.6	43.7	
Total ATD, formulation, and implementation through launch plus 30 days	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8	6.5	7.0	16.2	35.9	68.7	88.3	222.6	204.0	
Total LISA (NASA) cost	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8	6.5	7.0	16.2	35.9	68.7	88.3	222.6	204.0	
FULL COST OF:																	
NASA FTEs		0.8	1.3	2.7	4.2	2.3	11.2	8.9		1.7	3.3	5.3	9.4	10.4	30.2	27.7	
OSS Required Funding for LISA	3.8	2.2	5.3	15.5	26.1	16.7	69.6	65.9	6.5	5.3	12.9	30.5	59.3	77.9	192.4	176.3	
CONTRIBUTIONS OUTSIDE OF UPN 785-30 US (NON-LISA) CONTRIBUTIONS																	
Technology Flight Validation (NMP/ST-7)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	
Total US Cost (NASA)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	
ESA CONTRIBUTIONS																	
1.1 Management	0.2	0.1	0.2	0.7	1.1	0.0	2.3	2.2	0.4	0.2	0.6	1.6	2.5	2.3	7.5	6.9	
1.2 System Engineering/Integration Contractor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.0	2.0	2.1	5.7	5.2	
1.3 Mission Assurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	1.0	1.4	3.3	3.0	
1.4 Science	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.5	1.2	2.1	2.7	3.3	10.8	10.0	
1.4.4 Education & Public Outreach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	1.0	1.0	
1.5 Payload System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	1.3	2.7	7.7	9.8	23.1	21.1	
1.6 Flight System																	
1.6.1 Spacecraft (including FEEPs)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1	38.0	59.1	52.9	
1.7 Mission Operations System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.3	0.4	1.2	1.1	
1.9 Technology Development	4.3	2.6	4.0	8.8	11.4	0.0	31.1	29.6	4.3	2.6	4.0	8.8	11.4	0.0	31.1	29.6	
LISA Test Package	5.3	18.2	21.8	13.2	3.6	0.0	62.1	60.5	5.3	18.2	21.8	13.2	3.6	0.0	62.1	60.5	
Technology Flight Validation (SMART-2)	7.0	9.0	15.5	17.9	13.2	0.0	62.5	60.0	7.0	9.0	15.5	17.9	13.2	0.0	62.5	60.0	
Subtotal before Reserves	16.8	29.9	41.4	40.6	29.3	0.0	158.0	152.3	18.7	31.7	45.3	48.2	65.8	57.6	267.3	251.2	
Reserves	0.0	9.5	13.2	13.9	11.1	0.0	47.7	45.5	0.0	9.5	13.2	13.9	22.7	18.0	77.4	62.4	
Total ESA Cost	16.8	39.3	54.6	54.5	40.3	0.1	205.7	197.8	18.7	41.2	58.5	62.1	88.5	75.6	344.6	313.7	
Combined Contributions	19.8	53.8	74.7	66.3	44.0	2.9	261.3	251.6	21.7	55.6	78.5	73.8	92.1	78.4	400.3	367.5	
Total Mission Cost (All Sources)	23.6	56.8	81.3	84.4	74.2	21.9	342.1	326.4	28.2	62.6	94.8	109.7	160.8	166.7	622.9	571.5	

Table H-3: Implementation Cost Funding Profile (FY Costs in Real Year Dollars (\$M). Totals in RY and Fixed Year '03 Dollars)

Cost Element	Implementation											SUBTOTAL		TOTAL	
	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	Implementation		LIFE CYCLE	
												RY\$	FY03\$	RY\$	FY03\$
Start of ATD to Launch + 30 days (ATD, formulation and implementation)															
1.1 Management	8.8	10.3	13.3	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8	36.6	65.3	55.5
1.2 System Engineering/Integration Contractor	8.8	10.4	13.4	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2	36.9	66.3	56.2
1.3 Mission Assurance	2.5	2.9	3.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3	10.0	17.3	14.6
1.4 Science (excluding 1.4.4)	5.0	5.9	7.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6	20.9	36.4	30.9
1.4.4 Education & Public Outreach	1.1	1.3	1.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	4.7	8.2	7.0
1.5 Payload System	12.9	15.2	19.5	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.7	53.7	88.8	74.8
1.6 Flight System															
1.6.2 ATLO (SE&I Contractor)	6.0	7.1	9.1	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7	25.1	36.9	30.6
1.7 Mission Operations System	2.7	3.1	4.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	11.1	22.1	19.0
1.8 Launch Systems	25.9	30.5	39.3	36.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.4	108.1	132.4	108.1
1.9.4 Systems Verification	3.4	3.5	3.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	11.5	28.2	24.7
1.10 Mission Software	15.8	18.8	23.3	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.3	64.8	109.9	92.7
Subtotal before Reserves	93.0	109.0	138.5	128.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.4	383.4	643.4	543.7
Reserves	27.8	36.1	45.7	51.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.4	131.4	210.0	175.1
Total ATD, formulation, and implementation through launch plus 30 days	120.8	145.1	184.2	180.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	630.8	514.8	853.4	718.8
Launch + 30 Days to End of Mission												Enter each cost element			
1.1 Management	0.0	0.0	0.0	0.0	1.2	0.7	0.7	0.7	0.8	0.8	0.2	5.0	3.5	5.0	3.5
1.2 System Engineering/Integration Contractor	0.0	0.0	0.0	0.0	2.0	1.3	0.9	0.9	0.9	0.9	1.0	7.9	5.6	7.9	5.6
1.4 Science	0.0	0.0	0.0	0.0	13.2	13.6	12.7	13.1	10.8	11.1	11.5	86.0	60.0	86.0	60.0
1.4.4 Education & Public Outreach	0.0	0.0	0.0	0.0	1.6	1.7	0.9	0.9	0.9	0.8	0.8	7.5	5.3	7.5	5.3
1.5 Payload System	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.9	2.5	1.9
1.7 Mission Operations System	0.0	0.0	0.0	0.0	8.2	9.3	9.6	9.5	8.4	8.6	8.9	62.4	43.4	62.4	43.4
1.9.4 Systems Verification	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	3.6	2.7	3.6	2.7
1.10 Mission Software	0.0	0.0	0.0	0.0	3.3	1.4	1.4	1.5	1.5	1.6	1.6	12.2	8.6	12.2	8.6
Subtotal before Reserves	0.0	0.0	0.0	0.0	35.7	27.9	26.2	26.5	23.3	23.8	23.9	187.2	131.0	187.2	131.0
Reserves	0.0	0.0	0.0	0.0	8.4	4.2	4.1	4.1	3.9	4.0	3.9	32.6	22.9	32.6	22.9
Total from launch plus 30 days to end	0.0	0.0	0.0	0.0	44.0	32.1	30.3	30.7	27.1	27.8	27.8	219.8	154.0	219.8	154.0
Total LISA (NASA) cost	120.8	145.1	184.2	180.8	44.0	32.1	30.3	30.7	27.1	27.8	27.8	850.6	668.8	1,073.2	872.8
FULL COST OF:															
NASA FTEs	12.5	15.1	19.5	18.7	4.1	2.3	2.1	2.2	2.2	2.3	2.3	83.3	66.0	113.5	93.7
OSS Required Funding for LISA	108.2	130.0	164.6	162.0	39.9	29.8	28.2	28.5	24.9	25.5	25.5	767.3	602.8	959.7	779.1
CONTRIBUTIONS OUTSIDE OF UPN 785-30															
ESA CONTRIBUTIONS															
1.1 Management	3.2	3.8	4.9	4.5	0.4	0.3	0.3	0.3	0.3	0.3	0.1	18.2	14.7	25.7	21.6
1.2 System Engineering/Integration Contractor	2.4	2.8	3.6	3.3	0.5	0.3	0.2	0.2	0.2	0.3	0.3	14.2	11.3	19.8	16.5
1.3 Mission Assurance	1.7	1.9	2.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	6.6	11.4	9.6
1.4 Science	5.0	5.9	7.6	7.1	13.2	13.6	12.7	13.1	10.8	11.1	11.5	111.6	80.9	122.4	90.9
1.4.4 Education & Public Outreach	0.5	0.5	0.7	0.6	0.7	0.7	0.3	0.4	0.4	0.3	0.3	5.4	4.0	6.4	5.0
1.5 Payload System	12.9	15.2	19.5	18.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	68.3	55.6	91.3	76.7
1.6 Flight System															
1.6.1 Spacecraft (including FEEPs)	82.8	109.8	43.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	267.7	222.3	326.7	275.2
1.7 Mission Operations System	0.4	0.5	0.6	0.5	1.2	1.3	1.4	1.4	1.2	1.2	1.3	11.0	7.9	12.2	9.0
Subtotal before Reserves	108.8	140.3	82.2	68.5	18.5	16.2	14.9	15.3	12.9	13.2	13.4	504.3	403.4	771.6	654.6
Reserves	30.1	43.1	26.0	26.5	2.0	0.6	0.6	0.6	0.5	0.6	0.5	131.1	107.3	208.5	169.8
Total ESA Cost	139.0	183.4	108.2	95.0	20.5	16.8	15.5	15.9	13.5	13.8	13.9	635.4	510.7	980.0	824.4
Combined Contributions	139.0	183.4	108.2	95.0	20.5	16.8	15.5	15.9	13.5	13.8	13.9	635.4	510.7	1,035.7	878.2
Total Mission Cost (All Sources)	259.7	328.5	292.3	275.8	64.5	48.8	45.8	46.6	40.6	41.6	41.8	1,486.0	1,179.4	2,108.9	1,751.0

FY Costs in Real Year Dollars (\$M). Totals in RY and Fixed Year '03 Dollars

							SUBTOTAL								SUBTOTAL												SUBTOTAL		TOTAL			
	Adv Tech Dev						Adv Tech Dev		ATD plus Formulation						ATD plus Formulation		Implementation										Implementation		LIFE CYCLE			
Cost Element	PY	FY03	FY04	FY05	FY06	FY07	RYS	FY03\$	PY	FY03	FY04	FY05	FY06	FY07	RYS	FY03\$	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	RYS	FY03\$	RYS	FY03\$	
Start of ATD to Launch + 30 days (ATD, formulation and implementation) 1.1 Management 1.2 System Engineering/Integration Contractor 1.3 Mission Assurance 1.4 Science (excluding 1.4.4) 1.4.4 Education & Public Outreach 1.5 Payload System 1.6 Flight System 1.6.2 ATLO (SE&I Contractor) 1.7 Mission Operations System 1.8 Launch Systems 1.9 Technology Development (excl. 1.9.4) 1.9.4 Systems Verification 1.10 Mission Software Subtotal before Reserves Reserves	Enter each cost element																															
	0.6	0.3	0.4	2.0	2.9	0.1	6.3	6.0	1.0	0.6	1.6	4.3	6.7	6.1	20.4	18.9	8.8	10.3	13.3	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8	36.6	65.3	55.5	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7	1.5	3.6	7.5	7.7	21.2	19.4	8.8	10.4	13.4	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2	36.9	66.3	56.2	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.7	1.6	2.2	5.0	4.6	2.5	2.9	3.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3	10.0	17.3	14.6	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.5	1.2	2.1	2.7	3.3	10.8	10.0	5.0	5.9	7.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6	20.9	36.4	30.9	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.5	0.6	0.9	2.5	2.3	1.1	1.3	1.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	4.7	8.2	7.0	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	1.3	2.7	7.7	9.8	23.1	21.1	12.9	15.2	19.5	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.7	53.7	88.8	74.8	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	3.8	6.2	5.5	6.0	7.1	9.1	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7	25.1	36.9	30.6	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.8	2.2	1.9	2.7	8.6	8.0	2.7	3.1	4.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	11.1	22.1	19.0	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9	30.5	39.3	36.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.4	108.1	132.4	108.1	
	2.0	0.9	4.0	8.8	11.4	4.6	31.7	29.6	2.0	0.9	4.0	8.8	11.4	4.6	31.7	29.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	29.6
	1.2	1.2	1.4	3.7	3.3	3.3	14.1	13.2	1.2	1.2	1.4	3.7	3.3	3.3	14.1	13.2	3.4	3.5	3.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	11.5	28.2	24.7
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.8	3.6	10.2	12.9	30.5	27.9	15.8	18.8	23.3	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.3	64.8	109.9	92.7	
	3.8	2.4	5.8	14.5	17.6	8.0	52.1	48.7	6.5	6.4	15.4	32.2	56.1	57.4	174.0	160.3	93.0	109.0	138.5	128.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.4	383.4	643.4	543.7	
	0.0	0.5	0.8	3.7	12.6	11.0	28.7	26.1	0.0	0.5	0.8	3.7	12.6	30.9	48.6	43.7	27.8	36.1	45.7	51.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.4	131.4	210.0	175.1	
Total ATD, formulation, and implementation through launch plus 30 days	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8	6.5	7.0	16.2	35.9	68.7	88.3	222.6	204.0	120.8	145.1	184.2	180.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	630.8	514.8	853.4	718.8	
Launch + 30 Days to End of Mission	Enter each cost element																															
1.1 Management	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.7	0.7	0.8	0.8	0.2	5.0	3.5	5.0	3.5	
1.2 System Engineering/Integration Contractor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.3	0.9	0.9	0.9	0.9	1.0	7.9	5.6	7.9	5.6	
1.4 Science	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	13.6	12.7	13.1	10.8	11.1	11.5	86.0	60.0	86.0	60.0	
1.4.4 Education & Public Outreach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.7	0.9	0.9	0.9	0.8	0.8	7.5	5.3	7.5	5.3	
1.5 Payload System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1.9	2.5	1.9	
1.7 Mission Operations System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	9.3	9.6	9.5	8.4	8.6	8.9	62.4	43.4	62.4	43.4	
1.9.4 Systems Verification	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	3.6	2.7	3.6	2.7	
1.10 Mission Software	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	1.4	1.4	1.5	1.5	1.6	1.6	12.2	8.6	12.2	8.6	
Subtotal before Reserves	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.7	27.9	26.2	26.5	23.3	23.8	23.9	187.2	131.0	187.2	131.0	
Reserves	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.4	4.2	4.1	4.1	3.9	4.0	3.9	32.6	22.9	32.6	22.9	
Total from launch plus 30 days to end	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.0	32.1	30.3	30.7	27.1	27.8	27.8	219.8	154.0	219.8	154.0	
Total LISA (NASA) cost	3.8	3.0	6.6	18.2	30.2	19.0	80.8	74.8	6.5	7.0	16.2	35.9	68.7	88.3	222.6	204.0	120.8	145.1	184.2	180.8	44.0	32.1	30.3	30.7	27.1	27.8	27.8	850.6	668.8	1,073.2	872.8	
FULL COST OF:																																
NASA FTEs		0.8	1.3	2.7	4.2	2.3	11.2	8.9		1.7	3.3	5.3	9.4	10.4	30.2	27.7	12.5	15.1	19.5	18.7	4.1	2.3	2.1	2.2	2.2	2.3	2.3	83.3	66.0	113.5	93.7	
OSS Required Funding for LISA	3.8	2.2	5.3	15.5	26.1	16.7	69.6	65.9	6.5	5.3	12.9	30.5	59.3	77.9	192.4	176.3	108.2	130.0	164.6	162.0	39.9	29.8	28.2	28.5	24.9	25.5	25.5	767.3	602.8	959.7	779.1	
CONTRIBUTIONS OUTSIDE OF UPN 785-30 US (NON-LISA) CONTRIBUTIONS																																
Technology Flight Validation (NMP/ST-7)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	53.8	
Total US Cost (NASA)	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	3.0	14.4	20.0	11.7	3.6	2.8	55.7	53.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	53.8	
ESA CONTRIBUTIONS																																
1.1 Management	0.2	0.1	0.2	0.7	1.1	0.0	2.3	2.2	0.4	0.2	0.6	1.6	2.5	2.3	7.5	6.9	3.2	3.8	4.9	4.5	0.4	0.3	0.3	0.3	0.3	0.3	0.1	18.2	14.7	25.7	21.6	
1.2 System Engineering/Integration Contractor	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.0	2.0	2.1	5.7	5.2	2.4	2.8	3.6	3.3	0.5	0.3	0.2	0.2	0.2	0.3	0.3	14.2	11.3	19.8	16.5	
1.3 Mission Assurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	1.0	1.4	3.3	3.0	1.7	1.9	2.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	6.6	11.4	9.6	
1.4 Science	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.5	1.2	2.1	2.7	3.3	10.8	10.0	5.0	5.9	7.6	7.1	13.2	13.6	12.7	13.1	10.8	11.1	11.5	111.6	80.9	122.4	90.9	
1.4.4 Education & Public Outreach	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	1.0	1.0	0.5	0.5	0.7	0.6	0.7	0.3	0.4	0.4	0.3	0.3	0.3	5.4	4.0	6.4	5.0	
1.5 Payload System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	1.3	2.7	7.7	9.8	23.1	21.1	12.9	15.2	19.5	18.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	68.3	55.6	91.3	76.7	
1.6 Flight System																																
1.6.1 Spacecraft (including FEEPs)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.1	38.0	59.1	52.9	82.8	109.8	43.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	267.7	222.3	326.7	275.2	
1.7 Mission Operations System	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.3	0.4	1.2	1.1	0.4	0.5	0.6	0.5	1.2	1.3	1.4	1.4	1.2	1.2	1.3	11.0	7.9	12.2	9.0	
1.9 Technology Development	4.3	2.6	4.0	8.8	11.4	0.0	31.1	29.6	4.3	2.6	4.0	8.8	11.4	0.0	31.1	29.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	29.6	
LISA Test Package	5.3	18.2	21.8	13.2	3.6	0.0	62.1	60.5	5.3	18.2	21.8	13.2	3.6	0.0	62.1	60.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.1	60.5	
Technology Flight Validation (SMART-2)	7.0	9.0	15.5	17.9	13.2	0.0	62.5	60.0	7.0	9.0	15.5	17.9	13.2	0.0	62																	

H.1.2 LISA Funding Profile (Real Year \$M)

The JPL Team X and GSFC MICM cost models were used to arrive at constant year FY03 dollars. These amounts were time phased using standard project funding profiles developed by the GSFC Resources Analysis Office (RAO) who uses a historical database of large GSFC missions. The time phased constant year dollars were then inflated using the index provided by Code S.

Table H-4 shows the LISA Combined Budget. Section H.1.2 includes six pages documenting the process used to spread the budget dollars across the WBS Level 2 elements and fiscal years of the LISA

mission. The first three pages show the dollar values spread across the WBS Level 2 elements and fiscal years. The next three pages show the values (percentages) utilized in the calculations to derive the dollar values.

For example: under Technology Development, Management element, FY03; the formula is the total budget for Management (see LISA Total Mission section, Page 3) x the percentage of Management dollars estimated for Technology Development in FY03 x the value from the inflation matrix for FY03.

i.e. $\$70.3M * 0.0050 * 1.00 = \$0.3M$

Table H-4: LISA Combined Budget (\$M)

LISA COMBINED BUDGET									
TRIP Report NASA Contribution:	CY FY03 \$M	RY \$M	Tech Dev	Pre-A	Phase A	Phase B	Phase C/D	Phase E	Total
Management	59.0	70.3	6.3	1.2	3.1	9.8	44.8	5.0	70.3
System Engineering/Integration Contractor	61.8	74.2		1.2	4.8	15.2	45.2	7.9	74.2
Mission Assurance	14.6	17.3		0.4	0.9	3.7	12.3		17.3
Science	90.9	122.4		1.9	2.8	6.1	25.6	86.0	122.4
Education & Public Outreach	12.3	15.7		0.3	0.7	1.5	5.7	7.5	15.7
Payload System	76.7	91.3		1.9	3.6	17.5	65.7	2.5	91.3
Flight System	0.0	0.0							0.0
ATLO (SE&I Contractor)	30.6	36.9				6.2	30.7		36.9
Mission Operations System	62.4	84.6		1.1	2.8	4.6	13.6	62.4	84.6
Launch Systems	108.1	132.4					132.4		132.4
Technology Development	29.6	31.7	31.7						31.7
Systems Verification	27.5	31.8	14.1				14.1	3.6	31.8
Technology Flight Validation (ST-7)	53.8	55.7	55.7						55.7
Mission Software	101.3	122.1		2.6	4.8	23.1	79.3	12.2	122.1
SUBTOTAL WITHOUT CONTINGENCY:	728.5	886.2	107.8	10.5	23.5	87.8	469.4	187.2	886.2
Contingency (M\$)		242.6	28.7	0.0	0.0	19.9	161.4	32.6	242.6
Contingency (%)		27.4	26.6	0.0	0.0	22.7	34.4	17.4	
NASA TOTAL:	728.5	1,128.8	136.5	10.5	23.5	107.8	630.8	219.8	1,128.8
NOTE: ST-7/DRS sponsored by the NMP.									
ESA Contribution: (Includes member state contributions)			See NOTE below:						
Management	21.6	25.7	2.3	0.4	1.1	3.6	16.4	1.8	25.7
Mission System Engineering	16.5	19.8		0.3	1.3	4.1	12.1	2.1	19.8
Mission Assurance	9.6	11.4		0.2	0.6	2.5	8.1		11.4
Science	90.9	122.4		1.9	2.8	6.1	25.6	86.0	122.4
Education & Public Outreach	5.0	6.4		0.1	0.3	0.6	2.3	3.0	6.4
Member State Payload Contributions	76.7	91.3		1.9	3.6	17.5	65.7	2.5	91.3
Flight System	0.0	0.0							0.0
Spacecraft (including FEEPs)	275.2	326.7				59.1	267.7		326.7
Mission Operations System	9.0	12.2		0.2	0.4	0.7	2.0	9.0	12.2
Launch Systems	0.0	0.0							0.0
Technology Development	29.6	31.1	31.1						31.1
LISA Test Package	60.5	62.1	62.1						62.1
Technology Flight Validation (SMART-2)	60.0	62.5	62.5						62.5
Spacecraft Software	0.0	0.0							0.0
SUBTOTAL WITHOUT CONTINGENCY:	654.6	771.6	158.0	5.0	10.1	94.1	399.8	104.5	771.6
Contingency (M\$)		208.5	47.7	0.0	0.0	29.6	125.7	5.4	208.5
Contingency (%)		27.0	30.2	0.0	0.0	31.5	31.5	5.1	
ESA TOTAL:	654.6	980.0	205.7	5.0	10.1	123.7	525.6	109.9	980.0
TOTAL FOR LISA MISSION:		2,108.9	342.1	15.6	33.7	231.5	1,156.3	329.6	2,108.9
NOTE: Accounting of space activities varies considerably across Europe. Consequently, European goods and services contributed to the LISA Mission are costed for TRIP as if they were provided by traditional NASA suppliers.									

LISA Funding Profile - TRIP
Real Year (\$M) and Spreading Matrix Percentages (%)

PROGRAM ELEMENTS (Includes 3 S/C, plus chem. propulsion modules)	Dollars	Row	Launch																			
	To Spread (FY03\$M)	Totals	PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	TOTAL	
TECHNOLOGY DEVELOPMENT																						
NASA Contribution:																						
Management	6.3		0.6	0.3	0.4	2.0	2.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	
Technology Development	31.7		2.0	0.9	4.0	8.8	11.4	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	
Systems Verification	14.1		1.2	1.2	1.4	3.7	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	
NMP/ST-7 Distrubance Reduction System	55.7		3.0	14.4	20.0	11.7	3.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	
SUBTOTAL WITHOUT CONTINGENCY:	107.8		6.8	16.9	25.8	26.2	21.3	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	107.8	
Contingency	28.7		0.0	0.5	0.8	3.7	12.6	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.7	
NASA SUBTOTAL:	136.5		6.8	17.4	26.7	29.9	33.9	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	136.5	
ESA Contribution:																						
Management	2.3		0.2	0.1	0.2	0.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	
Technology Development	31.1		4.3	2.6	4.0	8.8	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	
LISA Test Package	62.1		5.3	18.2	21.8	13.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.1	
SMART-2 Mission	62.5		7.0	9.0	15.5	17.9	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	
SUBTOTAL WITHOUT CONTINGENCY:	158.0		16.8	29.9	41.4	40.6	29.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	158.0	
Contingency	47.7		0.0	9.5	13.2	13.9	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.7	
ESA SUBTOTAL:	205.7		16.8	39.3	54.6	54.5	40.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	205.7	
TECHNOLOGY DEVELOPMENT TOTAL:	342.1		23.6	56.8	81.3	84.4	74.2	21.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	342.1	
PRE-PHASE A DEFINITION																						
NASA Contribution:																						
Management	1.2		0.5	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	
System Engineering/Integration Contractor	1.2		0.1	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	
Mission Assurance	0.4		0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	
Science	1.9		0.9	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	
Education & Public Outreach	0.3		0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	
Payload System	1.9		0.7	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	
Mission Operations System	1.1		0.6	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	
Mission Software	2.6		0.0	1.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	
SUBTOTAL WITHOUT CONTINGENCY:	10.5		2.7	4.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	
Contingency	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NASA SUBTOTAL:	10.5		2.7	4.0	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	
ESA Contribution																						
Management	0.4		0.2	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	
System Engineering	0.3		0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	
Mission Assurance	0.2		0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	
Science	1.9		0.9	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	
Education & Public Outreach	0.1		0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	
Payload System	1.9		0.7	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	
Mission Operations System	0.2		0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	
Spacecraft Software	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SUBTOTAL WITHOUT CONTINGENCY:	5.0		1.9	1.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	
Contingency	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ESA SUBTOTAL:	5.0		1.9	1.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	
PRE-PHASE A TOTAL:	15.6		4.6	5.8	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	
PHASE A DEFINITION																						
NASA Contribution:																						
Management	3.1		0.0	0.0	0.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	
System Engineering/Integration Contractor	4.8		0.0	0.0	1.1	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	
Mission Assurance	0.9		0.0	0.0	0.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	
Science	2.8		0.0	0.0	0.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	
Education & Public Outreach	0.7		0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	
Payload System	3.6		0.0	0.0	0.9	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	
Mission Operations System	2.8		0.0	0.0	0.6	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	
Mission Software	4.8		0.0	0.0	1.3	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	
SUBTOTAL WITHOUT CONTINGENCY:	23.5		0.0	0.0	5.8	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	
Contingency	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NASA SUBTOTAL:	23.5		0.0	0.0	5.8	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.5	
ESA Contribution																						
Management	1.1		0.0	0.0	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	
System Engineering	1.3		0.0	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	
Mission Assurance	0.6		0.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	
Science	2.8		0.0	0.0	0.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	
Education & Public Outreach	0.3		0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0							

LISA Funding Profile - TRIP
Real Year (\$M) and Spreading Matrix Percentages (%)

PROGRAM ELEMENTS (Includes 3 S/C, plus chem. propulsion modules)	Dollars	II	PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	Launch										TOTAL
	To Spread (FY03\$M)	Row Totals										FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19		
Management	9.8	II	0.0	0.0	0.0	0.0	3.8	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8
System Engineering/Integration Contractor	15.2	II	0.0	0.0	0.0	0.0	7.5	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2
Mission Assurance	3.7	II	0.0	0.0	0.0	0.0	1.6	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
Science	6.1	II	0.0	0.0	0.0	0.0	2.7	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
Education & Public Outreach	1.5	II	0.0	0.0	0.0	0.0	0.6	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
Payload System	17.5	II	0.0	0.0	0.0	0.0	7.7	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5
Flight System: ATLO	6.2	II	0.0	0.0	0.0	0.0	2.3	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2
Mission Operations System	4.6	II	0.0	0.0	0.0	0.0	1.9	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6
Mission Software	23.1	II	0.0	0.0	0.0	0.0	10.2	12.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.1
SUBTOTAL WITHOUT CONTINGENCY:	87.8	II	0.0	0.0	0.0	0.0	38.4	49.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.8
Contingency	19.9	II	0.0	0.0	0.0	0.0	0.0	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.9
NASA SUBTOTAL:	107.8	II	0.0	0.0	0.0	0.0	38.4	69.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	107.8
ESA Contribution:		II																				
Management	3.6	II	0.0	0.0	0.0	0.0	1.4	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
System Engineering	4.1	II	0.0	0.0	0.0	0.0	2.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
Mission Assurance	2.5	II	0.0	0.0	0.0	0.0	1.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
Science	6.1	II	0.0	0.0	0.0	0.0	2.7	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1
Education & Public Outreach	0.6	II	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Payload System	17.5	II	0.0	0.0	0.0	0.0	7.7	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.5
Spacecraft	59.1	II	0.0	0.0	0.0	0.0	21.1	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.1
Mission Operations System	0.7	II	0.0	0.0	0.0	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Spacecraft Software	0.0	II	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUBTOTAL WITHOUT CONTINGENCY:	94.1	II	0.0	0.0	0.0	0.0	36.6	57.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	94.1
Contingency	29.6	II	0.0	0.0	0.0	0.0	11.6	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.6
ESA SUBTOTAL:	123.7	II	0.0	0.0	0.0	0.0	48.2	75.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123.7
PHASE B TOTAL:	231.5	II	0.0	0.0	0.0	0.0	86.6	144.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	231.5
PHASE C/D		II																				
NASA Contribution:		II																				
Management	44.8	II	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.3	13.3	12.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.8
System Engineering/Integration Contractor	45.2	II	0.0	0.0	0.0	0.0	0.0	0.0	8.8	10.4	13.4	12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	45.2
Mission Assurance	12.3	II	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.9	3.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3
Science	25.6	II	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.9	7.6	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.6
Education & Public Outreach	5.7	II	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.3	1.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7
Payload System	65.7	II	0.0	0.0	0.0	0.0	0.0	0.0	12.9	15.2	19.5	18.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.7
Flight System: ATLO	30.7	II	0.0	0.0	0.0	0.0	0.0	0.0	6.0	7.1	9.1	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.7
Mission Design & Operations	13.6	II	0.0	0.0	0.0	0.0	0.0	0.0	2.7	3.1	4.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6
Launch Systems	132.4	II	0.0	0.0	0.0	0.0	0.0	0.0	25.9	30.5	39.3	36.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.4
Systems Verification	14.1	II	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.5	3.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1
Mission Software	79.3	II	0.0	0.0	0.0	0.0	0.0	0.0	15.8	18.8	23.3	21.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	79.3
SUBTOTAL WITHOUT CONTINGENCY:	469.4	II	0.0	0.0	0.0	0.0	0.0	0.0	93.0	109.0	138.5	128.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	469.4
Contingency	161.4	II	0.0	0.0	0.0	0.0	0.0	0.0	27.8	36.1	45.7	51.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.4
NASA SUBTOTAL:	630.8	II	0.0	0.0	0.0	0.0	0.0	0.0	120.8	145.1	184.2	180.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	630.8
ESA Contribution:		II																				
Management	16.4	II	0.0	0.0	0.0	0.0	0.0	0.0	3.2	3.8	4.9	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4
System Engineering	12.1	II	0.0	0.0	0.0	0.0	0.0	0.0	2.													

LISA Funding Profile - TRIP
Real Year (\$M) and Spreading Matrix Percentages (%)

PROGRAM ELEMENTS (Includes 3 S/C, plus chem. propulsion modules)	Dollars			Launch																			
	To Spread (FY03\$M)	Row Totals		PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	TOTAL	
System Engineering		2.1		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.2	0.2	0.2	0.3	0.3	0.0	2.1	
Science		86.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	13.6	12.7	13.1	10.8	11.1	11.5	0.0	86.0	
Education & Public Outreach		3.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.3	0.4	0.4	0.3	0.3	0.0	3.0	
Payload System		2.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	
Mission Operations System		9.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.3	1.4	1.4	1.2	1.2	1.3	0.0	9.0	
LISA Test Package		0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Spacecraft Software		0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SUBTOTAL WITHOUT CONTINGENCY:		104.5		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5	16.2	14.9	15.3	12.9	13.2	13.4	0.0	104.5	
Contingency		5.4		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.6	0.6	0.6	0.5	0.6	0.5	0.0	5.4	
ESA SUBTOTAL:		109.9		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5	16.8	15.5	15.9	13.5	13.8	13.9	0.0	109.9	
PHASE E TOTAL:		329.6		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.5	48.8	45.8	46.6	40.6	41.6	41.8	0.0	329.6	
LISA TOTAL MISSION:																							
NASA Contributiun:																							
Management	59.0	70.3		1.0	0.6	1.6	4.3	6.7	6.1	8.8	10.3	13.3	12.4	1.2	0.7	0.7	0.7	0.8	0.8	0.2	0.0	70.3	
System Engineering/Integration Contractor	61.8	74.2		0.1	0.7	1.5	3.6	7.5	7.7	8.8	10.4	13.4	12.5	2.0	1.3	0.9	0.9	0.9	0.9	1.0	0.0	74.2	
Mission Assurance	14.6	17.3		0.0	0.1	0.4	0.7	1.6	2.2	2.5	2.9	3.5	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.3	
Science	90.9	122.4		0.9	0.5	1.2	2.1	2.7	3.3	5.0	5.9	7.6	7.1	13.2	13.6	12.7	13.1	10.8	11.1	11.5	0.0	122.4	
Education & Public Outreach	12.3	15.7		0.0	0.2	0.3	0.5	0.6	0.9	1.1	1.3	1.7	1.6	1.6	1.7	0.9	0.9	0.9	0.8	0.8	0.0	15.7	
Payload System	76.7	91.3		0.7	0.8	1.3	2.7	7.7	9.8	12.9	15.2	19.5	18.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.3	
Flight System	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
ATLO (SE&I Contractor)	30.6	36.9		0.0	0.0	0.0	0.0	2.3	3.8	6.0	7.1	9.1	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.9	
Mission Operations System	62.4	84.6		0.6	0.3	0.8	2.2	1.9	2.7	3.1	4.0	3.7	8.2	9.3	9.6	9.5	8.4	8.6	8.9	0.0	84.6		
Launch Systems	108.1	132.4		0.0	0.0	0.0	0.0	0.0	0.0	25.9	30.5	39.3	36.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	132.4	
Technology Development	29.6	31.7		2.0	0.9	4.0	8.8	11.4	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.7	
Systems Verification	27.5	31.8		1.2	1.2	1.4	3.7	3.3	3.3	3.4	3.5	3.6	3.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8	
Technology Flight Validation	53.8	55.7		3.0	14.4	20.0	11.7	3.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.7	
Mission Software	101.3	122.1		0.0	1.0	2.8	3.6	10.2	12.9	15.8	18.8	23.3	21.4	3.3	1.4	1.4	1.5	1.5	1.6	1.6	0.0	122.1	
SUBTOTAL WITHOUT CONTINGENCY:	728.5	886.2		9.6	20.9	35.4	43.9	59.7	60.2	93.0	109.0	138.5	128.9	35.7	27.9	26.2	26.5	23.3	23.8	23.9	0.0	886.2	
Contingency		242.6		0.0	0.5	0.8	3.7	12.6	30.9	27.8	36.1	45.7	51.9	8.4	4.2	4.1	4.1	3.9	4.0	3.9	0.0	242.6	
NASA TOTAL:		1128.8		9.6	21.4	36.2	47.6	72.3	91.1	120.8	145.1	184.2	180.8	44.0	32.1	30.3	30.7	27.1	27.8	27.8	0.0	1128.8	
European Contributions:																							
Management	21.6	25.7		0.4	0.2	0.6	1.6	2.5	2.3	3.2	3.8	4.9	4.5	0.4	0.3	0.3	0.3	0.3	0.3	0.1	0.0	25.7	
Mission System Engineering	16.5	19.8		0.0	0.2	0.4	1.0	2.0	2.1	2.4	2.8	3.6	3.3	0.5	0.3	0.2	0.2	0.2	0.3	0.3	0.0	19.8	
Mission Assurance	9.6	11.4		0.0	0.1	0.3	0.5	1.0	1.4	1.7	1.9	2.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	
Science	90.9	122.4		0.9	0.5	1.2	2.1	2.7	3.3	5.0	5.9	7.6	7.1	13.2	13.6	12.7	13.1	10.8	11.1	11.5	0.0	122.4	
Education & Public Outreach	5.0	6.4		0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.5	0.7	0.6	0.7	0.3	0.4	0.4	0.3	0.3	0.3	0.0	6.4	
Member State Payload Contributions	76.7	91.3		0.7	0.8	1.3	2.7	7.7	9.8	12.9	15.2	19.5	18.2	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.3	
Flight System	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Spacecraft (including FEEPs)	275.2	326.7		0.0	0.0	0.0	0.0	21.1	38.0	82.8	109.8	43.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	326.7	
Mission Operations System	9.0	12.2		0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.5	0.6	0.5	1.2	1.3	1.4	1.4	1.2	1.2	1.3	0.0	12.2	
Launch Systems	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Technology Development	29.6	31.1		4.3	2.6	4.0	8.8	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	
LISA Test Package	60.5	62.1		5.3	18.2	21.8	13.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.1	
Technology Flight Validation (SMART-2)	60.0	62.5		7.0	9.0	15.5	17.9	13.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	
Spacecraft Software	0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
SUBTOTAL WITHOUT CONTINGENCY:	654.6	771.6		18.7	31.7	45.3	48.2	65.8															

LISA Funding Profile - TRIP
Real Year (\$M) and Spreading Matrix Percentages (%)

[illegible]

PROGRAM ELEMENTS (Includes 3 S/C, plus chem. propulsion modules)		Dollars To Spread (FY03\$M)	Row Totals	PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	Launch FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	TOTAL
Flight System: ATLO		0.1800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0700	0.1100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1800
Mission Operations System		0.0660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0276	0.0384	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0660
Mission Software		0.2050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0920	0.1130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2050
ESA Contribution:																						
Management		0.1495	0.0000	0.0000	0.0000	0.0000	0.0000	0.0593	0.0902	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1495
System Engineering		0.2210	0.0000	0.0000	0.0000	0.0000	0.0000	0.1105	0.1105	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2210
Mission Assurance		0.2300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0988	0.1312	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2300
Science		0.0600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0276	0.0324	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0600
Education & Public Outreach		0.1125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0460	0.0665	0.0000	0.0000	0.0000	0.0000	0.0065	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1125
Payload System		0.2050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0920	0.1130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2050
Spacecraft		0.1921	0.0000	0.0000	0.0000	0.0000	0.0000	0.0700	0.1221	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1921
Mission Operations System		0.0660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0276	0.0384	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0660
Spacecraft Software		0.2050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0920	0.1130	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2050
PHASE C/D																						
NASA Contribution:																						
Management		0.6205	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1278	0.1458	0.1824	0.1645	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6205
System Engineering/Integration Contractor		0.5966	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1229	0.1402	0.1754	0.1581	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5966
Mission Assurance		0.6880	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1492	0.1645	0.1958	0.1785	0.0								

LISA Funding Profile - TRIP
Real Year (\$M) and Spreading Matrix Percentages (%)

PROGRAM ELEMENTS (Includes 3 S/C, plus chem. propulsion modules)	Dollars		II																			
	To Spread (FY03\$M)	Row Totals	II	PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	Launch FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	TOTAL
Technology Development		1.0000	II	1.0000																		
Systems Verification		1.0000	II	1.0000	LISA Test Package																	
Technology Flight Validation		1.0000	II	1.0000	SMART-II Mission																	
Mission Software		1.0000	II	1.0000	S/C Software																	
Contingency			II																			

H.1.3 Independent Cost Estimate

The independent cost estimate prepared by the JPL Systems Management Office is shown in Table H-5.

The assumptions are based on the schedules identified in Section H.2:

- Phase A activities will begin in February 2004 lasting for ~ 18 months.
- Phase B activities will begin in August 2005 lasting for ~ 2 years.
- Phases C/D will begin in October 2007 lasting ~ 4 years, with launch planned for August 2011.
- Detailed design is ~ 12 months
- Manufacturing is ~ 18 months
- Integration and testing is ~ 9 months
- ATLO is ~ 9 months
- The costing focused on the first 3 activities in Phase C/D for the instruments and spacecrafts using a combination of models and analogy. Only internal JPL models and databases were used at this time. External sources (Aerospace, SAIC, MCR, etc) will be used when the project requires an update to the cost estimate prior to entering Phase B and Phase C/D.
- Phases A and B costs were determined as a percentage of the Phases C/D costs, as was ATLO in Phases C/D. The Phase B costs and reserve (50%) are higher than normal missions because of the technology development activities that need to be completed prior to entering Phases C/D.
- Phases C/D reserves are ~ 30%, no reserve is carried on the ELV.
- Phase E is estimated at 6 years total, 1 year checkout/commissioning and 5 years operations; the reserve is 15%.
- The cost has a $\pm 15\%$ uncertainty resulting in a cost range of \$680M to \$922M before reserves. Reserves of \$207M were calculated as specified above on the mid-point of the cost range

and added to the cost range to give a total mission cost range of \$888M to \$1128M in FY'03\$ for Phases A thru E. The midpoint with reserves is \$1008M.

	Costs in FY03 \$M with reserves	
	JPL ICE	LISA Estimate
Phase A/B	146.1	222.6
Phase C/D	733.0	630.8
Phase E	129.0	219.8
Total	1,008.1	1,073.2

LISA Project Response:

The LISA Project estimate compares favorably with the JPL ICE at the total level. This agreement was expected since the JPL Team X Model and the GSFC MICM models were the basis for the LISA budget. The differences in the formulation and implementation phase estimates are due to the LISA Project's emphasis on early planning and technology development as compared to the average project represented by the JPL Team X Model. Since the LISA estimate is well within the uncertainty range of the ICE, no reconciliation of the two estimates is necessary.

Table H-5: LISA Independent Cost Estimate

Schedule Durations				
Phase A/B	3.5 Yrs			18 mo. Phase A, 24 mo. Phase B
Phase C/D	4 Yrs			
Phase E	6 Yrs			1 yr checkout, 5 years ops
Launch	08/2011			
Costs in FY03 \$M				
Phase A/B	\$97.4		Without reserves	
Phase A	12.2			
Phase B	85.2			
Reserves		48.7		
Phase C/D	591.8		Without reserves	
Mgmt	9.5		2% of Dev – L/V-Res-Mgmt	
Sys Eng	15.8		5% of S/C + Inst.	
MA	18.7		4% of Dev – L/V-Res	
Science	4.0		\$200k * duration * FTE	5 FTEs for Phase C/D timeframe
Spacecraft	165.0		Models / Analogy	
Instrument	150.0		Model	
Software	10.0		Starlight number	
ALTO	113.8		Analogy	35% of the S/C, Inst, & S/W
ELV	105.0		Lookup Table for Team X	
Reserves		141.2	30% of Dev – L/V – Res	30% of C/D costs – ELV & Res
Phase E	112.2		Without reserves	
Mgmt	10.2		10% of OpsSci + MODA	
Science	12.0		\$200K * duration * FTE	10 FTEs for Phase E timeframe
MO&DA	90.0		Model	
Reserves		16.8	15% of Ops – Ops Res	15%
Totals	801.3		Without Reserves	
Cost Range	\$681.1 - \$921.5		Without Reserves	Represents an uncertainty of \pm -15%
Total Reserves	\$206.7			Calculated on mid-point of cost range
Total Cost Range	\$887.9 – \$1,128.3			

H.1.4 NASA Workforce

Table H-6 shows the NASA workforce estimate. The LISA staffing plan shows the full time equivalent (FTE) civil servant staffing that relate to the LISA funding profile, using the current loaded labor rates, inflated by the Code S inflation index.

Section H.1.3 includes two pages documenting the process used to estimate FTEs and spreading them across the WBS Level 2 elements and fiscal years of the LISA mission. These pages show: the dollar values from the budget contained in Appendix H.1.2; the number of FTEs spread across the WBS Level 2 elements and fiscal years; and the values utilized in the formulas for calculating the full cost of the FTEs.

Table H-6: NASA Workforce

	FORMULATION							IMPLEMENTATION										TOTAL
	PY	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	
FTE	4.9	8.5	16.0	25.0	43.0	46.0	53.8	62.9	78.8	73.4	15.6	8.3	7.6	7.6	7.3	7.4	7.2	473.4
RY \$		1.7	3.3	5.3	9.4	10.4	12.5	15.1	19.5	18.7	4.1	2.3	2.1	2.2	2.2	2.3	2.3	113.5
CY \$		1.7	3.2	5.0	8.6	9.2	10.8	12.6	15.8	14.7	3.1	1.7	1.5	1.5	1.5	1.5	1.4	93.7

H.1.5 NASA Facilities

Table H-7 shows the cost of NASA facilities and equipment used for LISA. These are located at the GSFC and will be used during the Integration & Test activity. The facilities and equipment are located in:

- Building 7, the Payload Test Facility
- Building 10, the Environmental Test Laboratory
- Building 29, the Spacecraft Systems Development & Integration Facility

Table H-7: LISA Observatory & Constellation NASA Facility & Equipment Requirements (\$K)

Test	Facility	Days	Cost / month	FY08	FY09	FY10	FY11	Total Cost
Cleanroom Acquisition	SSDIF B29	761	43.3	201.8	624.0	643.3	442.4	1911.4
EMI/EMC	EMI Facility/B7	50	1.9		22.8	94.1		116.9
TV Instrumentation	SES Chamber B10		223.8		268.8			268.8
TV Fixturing	SES Chamber B10		335.7		403.2			403.2
TV Dry Run	SES Chamber B10		55.95		67.2			67.2
Vibration Test	Vibration facility B10	60	7.4		88.9	458.1		546.9
Thermal Vac Test	SES Chamber B10	180	300.0		720.6	1485.6		2206.2
Observatory Shock Test	SES Chamber B10	20	5		30.0	92.9		122.9
Total I&T Costs				201.8	2225.5	2773.9	442.4	5,643.5

H.1.6 Master Equipment List

LISA Master Equipment List, Detailed Mass and Power Budget spreadsheet follows:

Mission Element	Sub-system	Component	Fit Qty	Mass			CBE + Contin.	Power		CBE + Contin.
				Each	CBE Total	Mass Growth Cont. (%)		Each	CBE Total	
USA Flight System (3 Wet Spacecraft and Launch Vehicle Adapter)										
Science Module (Spacecraft +Payload)				Total	3093.00	12%	384.45	3562.31		
Power	Structures & Mechanisms			Total	75.90	30%	92.69	401.66		431.86
	Power	Structure & Mechanism	1	69.00	69.00	30%	20.70	89.70	1.00	1.30
		Secondary Structure	1	6.90	6.90	30%	2.07	8.97	0.00	0.00
		Solar Array	1	6.45	6.45	30%	8.65	37.50	11.00	14.30
		Battery	1	10.00	10.00	30%	1.93	8.38	0.00	0.00
Command & Data Handling	Power Controller Distribution Unit (PCDU)	1	12.40	12.40	30%	3.00	13.00	5.00	6.50	
						3.72	16.12	6.00	7.80	
	CPS	1	15.90	15.90	30%	4.77	20.67	25.00	32.50	
Telecom	Transponders			Total	19.60	30%	5.88	25.48		110.50
	RFDU	2	3.50	7.00	30%	2.10	9.10	12.00	24.00	
	SSPA	2	1.00	1.00	30%	0.30	1.30	1.00	1.30	
	TWT	0	0.75	0.00	30%	0.84	3.64	60.00	78.00	
	HG Antenna	2	3.00	6.00	30%	0.00	0.00	0.00	0.00	
Attitude Control	LG Antenna	4	0.20	0.80	30%	1.80	7.80	0.00	0.00	
	Cabling	1	2.00	2.00	30%	0.24	1.04	0.00	0.00	
	Ster Camera Assembly		Total	18.52	30%	5.56	24.08	48.60	63.18	
Thermal Control	SC Optical Head	4	0.74	2.96	30%	0.89	3.85	6.00	1.80	
	SC Electronics	2	0.70	1.40	30%	0.42	1.82	15.80	4.74	
	Sun Sensor	2	0.08	0.16	30%	0.05	0.21	0.00	0.00	
	Art Anomaly Detector	1	0.20	0.20	30%	0.06	0.26	0.00	0.00	
	Magnetometer Assembly	1	0.16	0.16	30%	0.05	0.23	0.80	1.04	
	FEEP El Clusters	6	1.77	10.62	30%	3.19	13.81	16.00	20.80	
	HGA Drive	2	0.50	1.00	30%	0.30	1.30	0.00	0.00	
	HD Mechanism	2	1.00	2.00	30%	0.60	2.60	5.00	3.00	
	HD Electronics	2	1.00	2.00	30%	0.60	2.60	5.00	3.00	
	MJI Blankets	1	4.00	4.00	30%	3.30	14.30	0.00	0.00	
Cabling	Radiators	1	6.00	6.00	30%	1.20	5.20	0.00	0.00	
	Paints	1	1.00	1.00	30%	1.80	7.80	0.00	0.00	
Cables & Harness						0.30	1.30	0.00	0.00	
	Cables & Harness	1	21.00	21.00	30%	6.30	27.30	0.00	0.00	

Mission Element	Sub-system	Component	Fit Qty	Mass			Power			CBE + Contin.		
				Each	CBE Total	Mass Growth Cont. (%)	Mass Growth Cont. (kg)	Each	CBE Total		Power Growth Cont. (%)	
Payload	Optical Assembly			Total	118.20	30%	35.46	Total	153.66	30%	48.48	210.98
		Telescope	2	6.50	13.00	30%	19.89	0.00	124.60	30%	37.38	161.98
		Optical Bench	2	5.60	11.20	30%	3.36	0.00	0.00	30%	0.00	0.00
		OA Structure	2	5.00	10.00	30%	3.00	0.00	9.00	30%	2.70	11.70
		LASER Assembly							0.00	30%	0.00	0.00
		LASER Head	4	2.00	8.00	30%	2.40	0.00	0.00	30%	0.00	0.00
		LASER Electronics	2	2.00	4.00	30%	1.20	37.00	74.00	30%	22.20	96.20
		Fiber Positioner	2	0.30	0.60	30%	0.18	0.00	0.00	30%	0.00	0.00
		Interferometer Electronics										
		IE Front Unit	2	1.50	3.00	30%	0.90	5.20	10.40	30%	3.12	13.52
		IE Digital Unit	2	3.50	7.00	30%	2.10	8.00	16.00	30%	4.80	20.80
		USO	2	2.00	4.00	30%	1.20	0.60	1.20	30%	0.36	1.56
		UV Discharger	2	0.50	1.00	30%	0.30	3.00	6.00	30%	1.80	7.80
		Instrument Control Electronics	1	4.50	4.50	30%	1.35	8.00	8.00	30%	2.40	10.40
	Gravitational Reference Sensor Assy			Total	19.00	30%	5.70	Total	11.00	30%	3.30	14.30
		Inertial Reference Sensor										
		Inertial Sensor	2	6.50	13.00	30%	3.90	0.00	0.00	30%	0.00	0.00
		IHS Electronics	2	2.00	4.00	30%	1.20	5.20	10.00	30%	3.00	13.00
		Mechanisms	1	2.00	2.00	30%	0.60	1.00	1.00	30%	0.30	1.30
	Y-Tube Assembly			Total	15.00	30%	4.50	Total	1.00	30%	0.30	1.30
		Y-Structure	1	13.00	13.00	30%	3.90	0.00	0.00	30%	0.00	0.00
		Mechanisms	1	2.00	2.00	30%	0.60	1.00	1.00	30%	0.30	1.30
	Thermal Control			Total	2.00	30%	0.60	Total	0.00	#DIV/0!	0.00	0.00
		Blankets	1	1.00	1.00	30%	0.30	0.00	0.00	30%	0.00	0.00
		Paints	1	1.00	1.00	30%	0.30	0.00	0.00	30%	0.00	0.00
	Payload Processor			Total	15.90	30%	4.77	Total	25.00	30%	7.50	32.50
		CPS	1	15.90	15.90	30%	4.77	25.00	25.00	30%	7.50	32.50
Propulsion Module				Total	212.49	30%	63.75	Total	264.00	30%	79.20	343.20
Structure				Total	101.00	30%	30.30	Total	0.00	#DIV/0!	0.00	0.00
		Primary Structure	1	51.00	51.00	30%	15.30	0.00	0.00	30%	0.00	0.00
		Secondary Structure	1	50.00	50.00	30%	15.00	0.00	0.00	30%	0.00	0.00
Chemical Propulsion				Total	85.40	30%	25.62	Total	98.00	30%	29.40	127.40
		Hydrazine Fuel Tank	2	8.10	16.20	30%	4.86	0.00	0.00	30%	0.00	0.00
		Oxidizer Tanks	2	5.67	11.34	30%	3.40	0.00	0.00	30%	0.00	0.00
		Pressurant Tank for Fuel	1	14.00	14.00	30%	4.20	0.00	0.00	30%	0.00	0.00
		Pressurant Tank for Oxidizer	1	7.40	7.40	30%	2.22	0.00	0.00	30%	0.00	0.00
		BiProp Thrusters 22N	2	2.00	4.00	30%	1.20	0.00	0.00	30%	0.00	0.00
		Flow Components & Pipework	1	27.16	27.16	30%	8.15	98.00	98.00	30%	28.40	127.40
		Brackets and Hardware	1	5.30	5.30	30%	1.59	0.00	0.00	30%	0.00	0.00
ACS				Total	22.09	30%	6.63	Total	131.00	30%	39.30	170.30
		ACS 0.1N thrusters	8	0.50	4.00	30%	1.20	5.20	12.00	30%	3.60	15.60
		Isolation Valves	17	0.57	9.60	30%	2.91	7.00	119.00	30%	35.70	154.70
		Tubing	1	8.00	8.00	30%	2.40	0.00	0.00	30%	0.00	0.00
		ACS 0.1N thrusters	1	0.40	0.40	30%	0.12	0.00	0.00	30%	0.00	0.00

Mission Element	Sub-system	Component	Fit Qty	Mass			Power			CBE + Contin.			
				Each	CBE Total	Mass Growth Cont. (%)	Mass Growth Cont. (kg)	Each	CBE Total	Power Growth Cont. (%)	Power Growth Cont. (W)	CBE + Contin.	
Thermal Control	MLI Blankets Heaters Paints		1	Total	4.00	30%	1.20	Total	35.00	30%	10.50	45.50	
				2.00	2.00	30%	0.60	0.00	0.00	30%	0.00	0.00	
				1.00	1.00	30%	0.30	35.00	35.00	30%	10.50	45.50	
				1.00	1.00	30%	0.30	0.00	0.00	30%	0.00	0.00	
Propellant L/V Adapter (5%) (kg)				Total	1359.00	0%	0.00	Total	0.00	0%	0.00	0.00	
				Total	169.63	0%	0.00	Total	0.00	0%	0.00	0.00	
Science Module Mass (kg)					926.90	30%	278.07	Payload Power		161.60	30%	48.48	210.08
Prop Module Mass (kg)					637.47	30%	191.24	SLC Bus Power		170.60	30%	51.18	221.78
Dry Flight System Mass (kg)					1564.37	30%	469.31	Prop + S/C Bus Power		434.60	30%	130.38	564.98
Propellant (kg)					1359.00	0%	0.00	Science Module Power		332.20	30%	99.66	431.86
Wet Flight System Mass (kg)					2923.37	16%	469.31	Science Module Power with 8% loss in wiring harness					466.41
TOTAL LAUNCH MASS (kg)					3093.00	12%	384.45						
Science Mass Fraction						22.67%		Square Meters of Array needed (for cruise phase bus power with 8% line loss)					3.45
LAUNCH VEHICLE CAPABILITY								Square Meters of Array needed (for operations phase Science Module power with 8% line loss)					2.64
Delta 4 Medium Performance Margin (kg)					4003								
					440.69								
					%	11.01%							

H.1.7 Work Breakdown Structure (WBS)

The LISA Project Work Breakdown Structure (WBS) is a product-oriented family tree division of the hardware, software, services and other unique effort associated with the LISA Project. It represents the way the work will be performed on the project and correlates directly to the LISA Supporting, Detailed Schedules (see Section H.2) and the LISA Formulation and Implementation Budgets (see Section H.1). This WBS is refined during the Pre-Formulation Stage.

1.0 LISA Total Project

1.1 Project Management

- 1.1.1 Project Management
- 1.1.2 Project Scientist
- 1.1.3 Business Management
- 1.1.4 Scheduling
- 1.1.5 Procurement Management
- 1.1.6 Project Support

1.2 System Engineering

- 1.2.1 System Engineering Management
- 1.2.2 Requirements
- 1.2.3 System Validation & Verification
- 1.2.4 Operations Concept Definition
- 1.2.5 System Architecture & Design
- 1.2.6 Interfaces and ICDs
- 1.2.7 Software System Engineering
- 1.2.8 Configuration Management
- 1.2.9 Risk Management
- 1.2.10 System Integration & Test (Support)

1.3 Mission Assurance

- 1.3.1 Mission Assurance Management
- 1.3.2 System Safety
- 1.3.3 Contamination Control
- 1.3.4 IV&V
- 1.3.5 Quality Assurance

1.4 Science

- 1.4.1 Mission Science Office
 - 1.4.1.1 Mission Scientist
 - 1.4.1.2 Science Team
 - 1.4.1.3 Science Management Plan
 - 1.4.1.4 Science Requirements
 - 1.4.1.5 Astrophysics & Waveform of Sources
 - 1.4.1.6 Data Analysis Methods
 - 1.4.1.7 Science Community Interface
- 1.4.2 Science Operations
 - 1.4.2.1 Operations Support
 - 1.4.2.2 Scientific Performance Characterization
- 1.4.3 Science Data Support
 - 1.4.3.1 Data Analysis
 - 1.4.3.2 Data Archiving & Distribution
 - 1.4.3.3 Participating Scientists
- 1.4.4 Education & Public Outreach

1.5 Payload System

- 1.5.1 Payload System Engineering / Management
- 1.5.2 Optical Assembly
 - 1.5.2.1 Optical Bench Assembly
 - 1.5.2.2 CCD Sensor
 - 1.5.2.3 Phase Detector
 - 1.5.2.4 Laser
 - 1.5.2.5 Optical Assembly Structure
 - 1.5.2.6 Star Tracker
 - 1.5.2.7 Telescope
 - 1.5.2.8 Optical Assembly Actuator
- 1.5.3 Gravitational Reference Sensor (GRS)
 - 1.5.3.1 Flight Test Mass
 - 1.5.3.2 Caging
 - 1.5.3.3 Housing & Electronics (Lightweight Test Mass)
 - 1.5.3.4 Charge Management Unit
 - 1.5.3.5 GRS Integration & Test

- 1.5.3.5.1 GRS EM I&T
 - 1.5.3.5.2 GRS FM1 I&T
 - 1.5.3.5.3 GRS FM2 I&T
 - 1.5.3.5.4 GRS FM3 I&T
- 1.5.4 Y-Tube Assembly
 - 1.5.4.1 Aft Fiber
 - 1.5.4.2 Structures
- 1.5.5 Payload Processor / Controller
- 1.5.6 Payload Integration & Test
 - 1.5.6.1 Optical Bench Assembly Initial Integration (Dummy GRS)
 - 1.5.6.1.1 Set-Up Integration Facility & GSE
 - 1.5.6.1.2 Optical Bench Assembly EM I&T
 - 1.5.6.1.3 Optical Bench Assembly FM1 I&T
 - 1.5.6.1.4 Optical Bench Assembly FM2 I&T
 - 1.5.6.1.5 Optical Bench Assembly FM3 I&T
 - 1.5.6.2 Electro-Optical Integration (Dummy GRS)
 - 1.5.6.2.1 Electro-Optical EM I&T
 - 1.5.6.2.2 Electro-Optical FM1 I&T
 - 1.5.6.2.3 Electro-Optical FM2 I&T
 - 1.5.6.2.4 Electro-Optical FM3 I&T
 - 1.5.6.3 Optical Assembly Integration (Dummy GRS)
 - 1.5.6.3.1 Optical Assembly EM I&T
 - 1.5.6.3.2 Optical Assembly FM1 I&T
 - 1.5.6.3.3 Optical Assembly FM2 I&T
 - 1.5.6.3.4 Optical Assembly FM3 I&T
 - 1.5.6.4 Optical Assembly Final Integration (Flight GRS)
 - 1.5.6.4.1 Optical Assembly EM Final I&T
 - 1.5.6.4.2 Optical Assembly FM1 Final I&T
 - 1.5.6.4.3 Optical Assembly FM2 Final I&T
 - 1.5.6.4.4 Optical Assembly FM3 Final I&T
 - 1.5.6.5 Y-Tube Integration
 - 1.5.6.5.1 Y-Tube EM I&T
 - 1.5.6.5.2 Y-Tube FM1 I&T
 - 1.5.6.5.3 Y-Tube FM2 I&T
 - 1.5.6.5.4 Y-Tube FM3 I&T

1.6 Flight System

1.6.1 Spacecraft (ESA)

1.6.1.1 ESA Acquisition Cycle

1.6.1.2 Spacecraft System Engineering / Management

1.6.1.3 Spacecraft Bus

1.6.1.3.1 Structures / Mechanisms Subsystem

1.6.1.3.1.1 Structure & Mechanism

1.6.1.3.1.2 Secondary Structure

1.6.1.3.2 Power Subsystem

1.6.1.3.2.1 Solar Array

1.6.1.3.2.2 Battery

1.6.1.3.2.3 Power Control Distribution Unit

1.6.1.3.3 Command & Data Handling Subsystem

1.6.1.3.4 Telecom Subsystem

1.6.1.3.4.1 Transponders

1.6.1.3.4.2 RFDU

1.6.1.3.4.3 SSPA

1.6.1.3.4.4 TWT

1.6.1.3.4.5 High Gain Antenna

1.6.1.3.4.6 Low Gain Antenna

1.6.1.3.4.7 Telecom Cabling

1.6.1.3.5 Attitude Control Subsystem

1.6.1.3.5.1 Star Camera Assembly Optical Head & Electronics

1.6.1.3.5.2 Sun Sensor

1.6.1.3.5.3 Aft Anomaly Detector

1.6.1.3.5.4 Magnetometer

1.6.1.3.5.5 FEED Assembly

1.6.1.3.5.6 High Gain Antenna Assembly Drive & Electronics

1.6.1.3.6 Thermal Subsystem

1.6.1.3.7 Cabling

1.6.1.3.8 Spacecraft Integration & Test

1.6.1.3.8.1 Spacecraft Bus EM I&T

	1.6.1.3.8.2	Spacecraft Bus FM1 I&T
	1.6.1.3.8.3	Spacecraft Bus FM2 I&T
	1.6.1.3.8.4	Spacecraft Bus FM3 I&T
1.6.1.4	Propulsion Module	
1.6.1.4.1	Structure	
	1.6.1.4.1.1	Primary Structure
	1.6.1.4.1.2	Secondary Structure
1.6.1.4.2	Chemical Propulsion	
	1.6.1.4.2.1	Fuel Tanks
	1.6.1.4.2.2	Pressurant Tanks
	1.6.1.4.2.3	Filters, Valves & Regulators
	1.6.1.4.2.4	RCS Thruster Assembly
	1.6.1.4.2.5	Heaters
1.6.1.4.3	Integration & Test	
	1.6.1.4.3.1	Propulsion Module EM I&T
	1.6.1.4.3.2	Propulsion Module FM1 I&T
	1.6.1.4.3.3	Propulsion Module FM2 I&T
	1.6.1.4.3.4	Propulsion Module FM3 I&T
1.6.1.5	Spacecraft I&T (Bus & Propulsion Module)	
	1.6.1.5.1	Spacecraft EM I&T
	1.6.1.5.2	Spacecraft Flight 1 I&T
	1.6.1.5.3	Spacecraft Flight 2 I&T
	1.6.1.5.4	Spacecraft Flight 3 I&T
1.6.2	Observatory Integration & Test	
1.6.2.1	Observatory EM I&T	
1.6.2.2	Observatory Flight 1 I&T	
1.6.2.3	Observatory Flight 2 I&T	
1.6.2.4	Observatory Flight 3 I&T	
1.6.3	Constellation Testing	
1.6.4	Final Integration (Pre-Launch)	
1.6.5	Launch Campaign	
	1.6.5.1	Constellation Launch Site Operations
	1.6.5.2	Constellation / Launch Vehicle Operations

1.7 Mission Operations System

- 1.7.1 Mission Ops Management
- 1.7.2 Mission Ops System Engineering
- 1.7.3 GDS Supporting Elements (Non-MOS GDS efforts)
- 1.7.4 Operations (Pre-Launch)
- 1.7.5 Missions Operations System V&V / Readiness Testing

1.8 Launch System

- 1.8.1 Spacecraft-To-Launch Vehicle Interface Definition, Verification & Coordination
- 1.8.2 Launch Vehicle Build, Storage & Pre-Ship Operations
- 1.8.3 Launch Services / Launch Site Operations

1.9 Technology

- 1.9.1 Technology Management
- 1.9.2 Disturbance Reduction System
 - 1.9.2.1 Gravitational Reference Sensor
 - 1.9.2.1.1 Housing Subsystem
 - 1.9.2.1.2 Vacuum Subsystem
 - 1.9.2.1.3 Caging Subsystem
 - 1.9.2.1.4 Proof Mass Subsystem
 - 1.9.2.1.5 Proof Mass Control Subsystem
 - 1.9.2.1.6 Sensing & Forcing Subsystem
 - 1.9.2.1.7 Charge Control Subsystem
 - 1.9.2.1.8 I&T Mechanisms
 - 1.9.2.1.9 Prototype GRS (Lab Verified)
 - 1.9.2.2 Thrusters
 - 1.9.2.2.1 Emitter
 - 1.9.2.2.2 Neutralizer
 - 1.9.2.2.3 Thruster Electronics
 - 1.9.2.2.4 Prototype Thruster
 - 1.9.2.3 DRS Controls
 - 1.9.2.3.1 Algorithms
 - 1.9.2.3.2 Simulator Test

- 1.9.3 Interferometry Measurement System
 - 1.9.3.1 Laser(s)
 - 1.9.3.2 Laser/Clock Noise Cancellation
 - 1.9.3.3 Stabilization
 - 1.9.3.4 Phase Meter
 - 1.9.3.5 Ultra Stable Structures
 - 1.9.3.6 IMS Tester
 - 1.9.3.7 Prototype IMS
- 1.9.4 System Verification
 - 1.9.4.1 Integrated Modeling
 - 1.9.4.1.1 Modeling Environment
 - 1.9.4.1.2 Quasi-Static Models
 - 1.9.4.1.3 Dynamic Models
 - 1.9.4.1.4 Phase Propagation Models
 - 1.9.4.1.5 End-To-End Models
 - 1.9.4.2 Test Bed Technology
 - 1.9.4.2.1 Phase 1 - Approaches
 - 1.9.4.2.2 Phase 2 - Development

1.10 Mission Software

- 1.10.1 Software Management
- 1.10.2 Software Requirements Document
- 1.10.3 Software Test Plan
- 1.10.4 Spacecraft Flight Software
- 1.10.5 Ground Data System (Mission Ops System)
- 1.10.6 Science Data System Software
- 1.10.7 IV&V

H.1.8 WBS Dictionary

While the LISA Work Breakdown Structure presented in Section H.1.7 represents a **subdivision** of the total work scope for the LISA Project, the Work Breakdown Structure Dictionary is provided to specifically **define** the work scope for each element. The work scope definition provided by the Work Breakdown Structure Dictionary ensures effective communication and mutual understanding by the LISA Team members of the work to be performed. It is refined during the Pre-Formulation Stage.

Table H-8: WBS Dictionary

WBS	DESCRIPTION	WBS DICTIONARY
1.0	LISA Total Project	This element summarizes the project management, system engineering, mission assurance, science, payload system, flight system, mission operations system, launch system, technology, and mission software effort for the entire LISA project.
1.1	Project Management	This element summarizes the effort for the LISA Project Management Office and includes: project management, project scientist, business management, scheduling, procurement management, and project support.
1.1.1	Project Management	This element contains the project management effort and includes all labor, subcontracts, materials and other direct costs.
1.1.2	Project Scientist	This element contains the effort for the project scientist at GSFC and includes coordination with the mission scientist to ensure the science requirements are met during the life of the mission. Includes all labor, subcontracts, materials and other direct costs.
1.1.3	Business Management	This element contains the business management effort (resource analysis) and includes all labor, subcontracts, materials and other direct costs.
1.1.4	Scheduling	This element contains the effort to develop, maintain and control the end-to-end LISA Project schedules and includes all labor, subcontracts, materials and other direct costs.
1.1.5	Procurement Management	This element contains the effort to manage and maintain external contracts and subcontracts with vendors, suppliers and team members. Includes all labor, subcontracts, materials and other direct costs.
1.1.6	Project Support	This element contains all other project support effort not identified in the other project management WBS elements such as logistics, graphics, ITAR coordination, MIS, etc. It includes all labor, subcontracts, materials and other direct costs.
1.2	System Engineering	This element summarizes the system engineering management, requirements, system validation & verification, operations concept definition, system architecture & design, interfaces & ICDs, S/W system engineering, configuration management, risk management and system I&T support effort.

WBS	DESCRIPTION	WBS DICTIONARY
1.2.1	System Engineering Management	This element contains the effort to manage the LISA system engineering process and to develop and maintain the System Engineering Management Plan, maintain a System Architect Team, conduct major system-level reviews, and develop and maintain communications and system engineering tools. Includes all labor, subcontracts, materials and other direct costs.
1.2.2	Requirements	This element contains the effort to define and maintain Level 1 and System Requirements, develop and maintain a requirements database, prepare the Disposal, Re-Entry & Decommission Plan, and prepare Environmental and Orbital Debris Assessments. Includes all labor, subcontracts, material and other direct costs.
1.2.3	System Validation & Verification	This element contains the effort to develop and maintain a project wide verification process of system interactions and a process to ensure that project requirements are met. Includes all labor, subcontracts, materials and other direct costs.
1.2.4	Operations Concept Definition	This element contains the effort to define and maintain an operations concept and includes all labor, subcontracts, materials and other direct costs.
1.2.5	System Architecture & Design	This element contains the effort to conduct system architecture trade studies, develop the architecture & design specification, and maintain the integrated modeling effort after the conclusion of the technology development program. Includes all labor, subcontracts, materials and other direct costs.
1.2.6	Interfaces and ICDs	This element contains the effort to develop and update ICDs and includes all labor, subcontracts, materials and other direct costs.
1.2.7	Software System Engineering	This element contains the effort to maintain flight software interface control documents between the subsystems on the bus, between the bus and payload, & between the constellation and the ground system. Includes all labor, subcontracts, materials and other direct costs.
1.2.8	Configuration Management	This element contains the effort to maintain configuration control of all drawings and documentation necessary to ensure the proper design, production and operations of the LISA system and includes all labor, subcontracts, materials and other direct costs.
1.2.9	Risk Management	This element contains the effort to develop and maintain a risk management plan and system and includes all labor, subcontracts, materials and other direct costs.
1.2.10	System Integration & Test (Support)	This element contains the effort to design, develop, and implement system level tests that reflect the interaction of observatory and constellation elements. It also includes development of an EMC/EMI plan and development/operations of system test beds after the conclusion of the technology development program. Includes all labor, subcontracts, materials and other direct costs.
1.3	Mission Assurance	This element summarizes the effort to perform mission assurance management, system safety, contamination control, IV&V, and quality assurance.

WBS	DESCRIPTION	WBS DICTIONARY
1.3.1	Mission Assurance Management	This element contains the effort to establish and maintain a flight assurance program and to develop and maintain the mission assurance guidelines and requirements. Includes all labor, subcontracts, materials and other direct costs.
1.3.2	System Safety	This element contains the effort to develop and maintain a safety program, and includes development of a Safety Data Package and a System Safety Plan. Includes all labor, subcontracts, materials and other direct costs.
1.3.3	Contamination Control	This element contains the effort to develop and maintain a contamination control program and includes all labor, subcontracts, materials and other direct costs.
1.3.4	IV&V	This element contains the effort to develop independent verification and validation processes for the onboard software and firmware and includes all labor, subcontracts, materials and other direct costs.
1.3.5	Quality Assurance	This element contains the effort to establish and maintain a project level quality assurance program and includes all labor, subcontracts, materials and other direct costs.
1.4	Science	This element summarizes the effort to maintain a mission science office, science operations, science data support, and education & public outreach.
1.4.1	Mission Science Office	This element summarizes the effort for the mission scientist, the science team, the Science Management Plan, Science Requirements, Astrophysics & Waveform of Sources, Data Analysis Methods and the Science Community Interface.
1.4.1.1	Mission Scientist	This element contains the effort for the mission scientist and includes all labor, subcontracts, materials and other direct costs.
1.4.1.2	Science Team	This element contains the effort to support the science team and includes all labor, subcontracts, materials and other direct costs.
1.4.1.3	Science Management Plan	This element contains the effort to determine a science management approach and develop and maintain a science management plan. Includes all labor, subcontracts, materials, and other direct costs.
1.4.1.4	Science Requirements	This element contains the effort to define and update the science requirements. Includes all labor, subcontracts, materials, and other direct costs.
1.4.1.5	Astrophysics & Waveform of Sources	This element contains the effort to develop the initial calculations of Astrophysics & Waveform of Sources, and provide updates throughout the life of the LISA mission. Includes all labor, subcontracts, materials, and other direct costs.
1.4.1.6	Data Analysis Methods	This element contains the effort to develop methods for analyzing LISA data in order to extract scientific results. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.4.1.7	Science Community Interface	This element contains the effort to develop and manage the participation of the astrophysics and fundamental physics communities in LISA science. Includes all labor, subcontracts, materials, and other direct costs.
1.4.2	Science Operations	This element summarizes the effort to provide operations support and scientific performance characterization.
1.4.2.1	Operations Support	This element contains the effort to receive and archive incoming science and scientific housekeeping data from the mission operations center, and calibrate, correct and format incoming data in units of strain for each polarization of the antenna. It also includes the recording of orbital elements describing detector location and orientation, verifying that incoming data meets the expectations of the science requirements, and ascertaining and advising on the need for adjustments to, or improvements in, the operational state of the LISA constellation. Includes all labor, subcontracts, materials, and other direct costs.
1.4.2.2	Scientific Performance Characterization	This element contains the effort to provide scientific performance characterization and includes all labor, subcontracts, materials and other direct costs.
1.4.3	Science Data Support	This element summarizes the effort to provide data analysis and data archiving & distribution and to support participating scientists.
1.4.3.1	Data Analysis	This element contains the effort to analyze strain data to extract astrophysical parameters of sources and catalog them with their astrophysical parameters. This includes preliminary analyses to enable other astrophysical observing systems to react to forecasts of extraordinary events, and includes all labor, subcontracts, materials and other direct costs.
1.4.3.2	Data Archiving & Distribution	This element contains the effort to archive and distribute intermediate data products and the catalog of gravitational wave sources to develop and maintain the science data management plan and a data archiving & distribution system. Includes all labor, subcontracts, materials and other direct costs.
1.4.3.3	Participating Scientists	This element contains the effort to manage direct participation (e.g., guest investigator program) by members of astrophysics and fundamental physics communities in the analysis and interpretation of LISA science data and includes all labor, subcontracts, materials and other direct costs.
1.4.4	Education & Public Outreach	This element contains the effort to provide education and public outreach. These costs may include public affairs announcements, video and audio type publications, public relation seminars, K-12 classroom presentations, college level seminars and involvement with public television programming. Includes all labor, subcontracts, materials and other direct costs.
1.5	Payload System	This element summarizes the effort to design, fabricate, assemble, integrate and test the payload system.

WBS	DESCRIPTION	WBS DICTIONARY
1.5.1	Payload System Engineering / Management	This element contains the effort to manage the engineering resources necessary to complete the payload systems engineering functions. These costs include personnel management, coordination between subsystems and carrying out of operational activities. Includes all labor, subcontracts, materials, and other direct costs.
1.5.2	Optical Assembly	This element summarizes the effort to design, fabricate, and assemble the optical assembly.
1.5.2.1	Optical Bench Assembly	This element contains the effort to design, fabricate, and assemble the optical bench assembly components such as the optical bench, dummy GRS, fiber positioner, optics, laser stabilization cavity, pre-mounting for CCD & diodes and the integration fixture. Includes all labor, subcontracts, materials, and other direct costs.
1.5.2.2	CCD Sensor	This element contains the effort to design, fabricate, assemble, integrate and test the CCD sensor. It includes the CCDs and the CCD electronics. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.2.3	Phase Detector	This element contains the effort to design, fabricate, assemble, and integrate and test the phase detector. It includes the diodes & hardware, pre-amplifiers, phase readout electronics and ultra stable oscillator. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.2.4	Laser	This element contains the effort to design, fabricate, assemble, and integrate and test the laser. It includes the fiber delivery system, laser stabilization electronics, laser, phase modulator and phase modulator electronics & data interface. Also, included are all labor, subcontracts, materials, and other direct costs.
1.5.2.5	Optical Assembly Structure	This element contains the effort to design, fabricate, assemble, and test the optical assembly structure. Includes all labor, subcontracts, materials, and other direct costs.
1.5.2.6	Star Tracker	This element contains the effort to design, fabricate, assemble, and test the start tracker. Includes all labor, subcontracts, materials, and other direct costs.
1.5.2.7	Telescope	This element contains the effort to design, fabricate, assemble, integrate and test the telescope. It includes the primary optics, secondary optics and the telescope structure. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.2.8	Optical Assembly Actuator	This element contains the effort to design, fabricate, assemble, integrate and test the optical assembly actuator. It includes the actuator mechanism and actuator electronics. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.3	Gravitational Reference Sensor (GRS)	This element summarizes the effort to design, fabricate, assemble, and integrate and test the gravitational reference sensor (GRS).

WBS	DESCRIPTION	WBS DICTIONARY
1.5.3.1	Flight Test Mass	This element contains the effort to design, fabricate, assemble, and test the flight test mass. Includes all labor, subcontracts, materials, and other direct costs.
1.5.3.2	Caging	This element contains the effort to design, fabricate, assemble, and test the caging. Includes all labor, subcontracts, materials, and other direct costs.
1.5.3.3	Housing & Electronics (Lightweight Test Mass)	This element contains the effort to design, fabricate, assemble, and integrate and test the housing & electronics (lightweight test mass). It includes the vacuum & structure, electrode housing, lightweight test mass & special caging, front end electronics and control electronics. It also includes all labor, subcontracts, materials, and other direct costs.
1.5.3.4	Charge Management Unit	This element contains the effort to design, fabricate, assemble, and integrate and test the charge management unit. It includes the UV lamps, UV switch and UV control. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.3.5	GRS I&T	This element summarizes the effort to integrate and test the gravitational reference sensor.
1.5.3.5.1	GRS EM I&T	This element contains the effort to integrate and test the gravitational reference sensor engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.5.3.5.2	GRS FM1 I&T	This element contains the effort to integrate and test the gravitational reference sensor flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.3.5.3	GRS FM2 I&T	This element contains the effort to integrate and test the gravitational reference sensor flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.3.5.4	GRS FM3 I&T	This element contains the effort to integrate and test the gravitational reference sensor flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.5.4	Y-Tube Assembly	This element summarizes the effort to design, fabricate, and assemble, the Y-tube assembly components.
1.5.4.1	Aft Fiber	This element contains the effort to design, fabricate, assemble, and test the aft fiber. Includes all labor, subcontracts, materials, and other direct costs.
1.5.4.2	Ultra Stable Structure	This element contains the effort to design, build, assemble, and integrate and test the ultra stable structure. It includes the radiator, Y-tube structure and aft bulkhead. Also included are all labor, subcontracts, materials, and other direct costs.
1.5.5	Payload Processor / Controller	This element contains the effort to design, fabricate, assemble, integrate and test the payload processor/ controller. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6	Payload Integration & Test	This element summarizes the effort to integrate and test the payload.

WBS	DESCRIPTION	WBS DICTIONARY
1.5.6.1	Optical Bench Assembly Initial Integration (Dummy GRS)	This element summarizes the effort to set up the integration facility & GSE and to perform the Optical Bench Assembly Initial Integration & Test of the engineering and flight model Payloads.
1.5.6.1.1	Set-Up Integration Facility & GSE	This element contains the effort to set up the integration facility & GSE and includes all labor, subcontracts, materials, and other direct costs.
1.5.6.1.2	Optical Bench Assembly EM I&T	This element contains the effort to integrate & test and pack, ship and deliver to ESA the Optical Bench Assembly for the Payload Engineering Model. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.1.3	Optical Bench Assembly FM1 I&T	This element contains the effort to integrate & test and pack, ship and deliver to ESA the Optical Bench Assembly for the Payload Flight Model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.1.4	Optical Bench Assembly FM2 I&T	This element contains the effort to integrate & test and pack, ship and deliver to ESA the Optical Bench Assembly for the Payload Flight Model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.1.5	Optical Bench Assembly FM3 I&T	This element contains the effort to integrate & test and pack, ship and deliver to ESA the Optical Bench Assembly for the Payload Flight Model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.2	Electro-Optical Integration (Dummy GRS)	This element summarizes the effort to perform the Electro-Optical Integration with the Dummy GRS of the engineering and flight model Payloads.
1.5.6.2.1	Electro-Optical EM I&T	This element contains the effort to integrate & test and pack, ship and deliver to NASA the electro-optical engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.2.2	Electro-Optical FM1 I&T	This element contains the effort to integrate & test and pack, ship and deliver to NASA the electro-optical flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.2.3	Electro-Optical FM2 I&T	This element contains the effort to integrate & test and pack, ship and deliver to NASA the electro-optical flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.2.4	Electro-Optical FM3 I&T	This element contains the effort to integrate & test and pack, ship and deliver to NASA the electro-optical flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.3	Optical Assembly Integration (Dummy GRS)	This element summarizes the effort to perform the Optical Assembly Integration with the Dummy GRS of the engineering and flight model Payloads.
1.5.6.3.1	Optical Assembly EM I&T	This element contains the effort to initially integrate and test the optical assembly engineering model. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.5.6.3.2	Optical Assembly FM1 I&T	This element contains the effort to initially integrate and test the optical assembly flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.3.3	Optical Assembly FM2 I&T	This element contains the effort to initially integrate and test the optical assembly flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.3.4	Optical Assembly FM3 I&T	This element contains the effort to initially integrate and test the optical assembly flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.4	Optical Assembly Final Integration (Flight GRS)	This element summarizes the effort to perform the Optical Assembly Final Integration with the Flight GRS of the engineering and flight model Payloads.
1.5.6.4.1	Optical Assembly EM Final I&T	This element contains the effort to perform final integration and test of the optical assembly engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.4.2	Optical Assembly FM1 Final I&T	This element contains the effort to perform final integration and test of the optical assembly flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.4.3	Optical Assembly FM2 Final I&T	This element contains the effort to perform final integration and test of the optical assembly flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.4.4	Optical Assembly FM3 Final I&T	This element contains the effort to perform final integration and test of the optical assembly flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.5	Y-Tube Integration	This element summarizes the effort to perform the Y-Tube Integration of the engineering and flight model Payloads.
1.5.6.5.1	Y-Tube EM I&T	This element contains the effort to integrate and test and pack, ship and delivery to NASA the Y-tube engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.5.2	Y-Tube FM1 I&T	This element contains the effort to integrate and test and pack, ship and delivery to NASA the Y-tube flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.5.3	Y-Tube FM2 I&T	This element contains the effort to integrate and test and pack, ship and delivery to NASA the Y-tube flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.5.6.5.4	Y-Tube FM3 I&T	This element contains the effort to integrate and test and pack, ship and delivery to NASA the Y-tube flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.6	Flight System	This element summarizes the effort to acquire, design, fabricate, assemble, integrate and test the ESA spacecraft and integrate and test the observatory.
1.6.1	Spacecraft (ESA)	This element summarizes the effort to acquire, design, fabricate, assemble, integrate and test the ESA spacecraft.

WBS	DESCRIPTION	WBS DICTIONARY
1.6.1.1	ESA Acquisition Cycle	This element represents the ESA acquisition process / cycle effort and is included for reference.
1.6.1.2	Spacecraft System Engineering / Management	This element contains the effort to manage the engineering resources necessary to complete the spacecraft systems engineering functions. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3	Spacecraft Bus	This element summarizes the effort to design, fabricate, and assemble the structures/ mechanisms, power, C&DH, telecom, ACS, thermal and cabling subsystems, and integrate and test the spacecraft bus.
1.6.1.3.1	Structures / Mechanisms Subsystem	This element summarizes the effort to design, fabricate, assemble, and test the structure & mechanism and secondary structure subsystems.
1.6.1.3.1.1	Structure & Mechanism	This element contains the effort to design, fabricate, assemble and test the structure & mechanism subsystem and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.1.2	Secondary Structure	This element contains the effort to design, fabricate, assemble, and test the secondary structure subsystem and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.2	Power Subsystem	This element summarizes the effort to design, fabricate, assemble, and test the solar array, battery, and power control distribution unit.
1.6.1.3.2.1	Solar Array	This element contains the effort to design, fabricate, assemble, and test the solar array and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.2.2	Battery	This element contains the effort to design, fabricate, assemble, and test the battery and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.2.3	Power Control Distribution Unit	This element contains the effort to design, fabricate, assemble, and test the power control distribution unit and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.3	Command & Data Handling Subsystem	This element contains the effort to design, fabricate, assemble, and test the command and data handling subsystem and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4	Telecom Subsystem	This element summarizes the effort to design, fabricate, assemble, and test the transponders, RFDU, SSPA, TWT, high gain antenna, low gain antenna, and telecom cabling.
1.6.1.3.4.1	Transponders	This element contains the effort to design, fabricate, assemble, and test the transponders and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4.2	RFDU	This element contains the effort to design, fabricate, assemble, and test the RFDU and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4.3	SSPA	This element contains the effort to design, fabricate, assemble, and test the SSPA and includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.6.1.3.4.4	TWT	This element contains the effort to design, fabricate, assemble, and test the TWT and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4.5	High Gain Antenna	This element contains the effort to design, fabricate, assemble, and test the high gain antenna and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4.6	Low Gain Antenna	This element contains the effort to design, fabricate, assemble, and test the low gain antenna and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.4.7	Telecom Cabling	This element contains the effort to design, fabricate, assemble, and test the telecom cabling and includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5	Attitude Control Subsystem	This element summarizes the effort to design, fabricate, assemble, and test the star camera assembly optical head & electronics, sun sensor, aft anomaly detector, magnetometer, FEEP assembly, and high gain antenna assembly drive & electronics.
1.6.1.3.5.1	Star Camera Assembly Optical Head & Electronics	This element contains the effort to design, fabricate, assemble, and test the star camera assembly optical head & electronics. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5.2	Sun Sensor	This element contains the effort to design, fabricate, assemble, and test the sun sensor. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5.3	Aft Anomaly Detector	This element contains the effort to design, fabricate, assemble, and test the aft anomaly detector. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5.4	Magnetometer	This element contains the effort to design, fabricate, assemble, and test the magnetometer. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5.5	FEEP Assembly	This element contains the effort to design, fabricate, assemble, and test the FEEP assembly. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.5.6	High Gain Antenna Assembly Drive & Electronics	This element contains the effort to design, fabricate, assemble, and test the high gain antenna assembly drive & electronics. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.6	Thermal Subsystem	This element contains the effort to design, procure, and build the thermal subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.7	Cabling	This element contains the effort to design, fabricate, assemble, and test the interconnecting cabling for the spacecraft bus. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.8	Spacecraft Bus Integration & Test	This element summarizes the effort to integrate and test the spacecraft bus engineering and flight models.

WBS	DESCRIPTION	WBS DICTIONARY
1.6.1.3.8.1	Spacecraft Bus EM Integration & Test	This element contains the effort to integrate and test the spacecraft bus engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.8.2	Spacecraft Bus FM1 Integration & Test	This element contains the effort to integrate and test the spacecraft bus flight model 1. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.8.3	Spacecraft Bus FM2 Integration & Test	This element contains the effort to integrate and test the spacecraft bus flight model 2. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.3.8.4	Spacecraft Bus FM3 Integration & Test	This element contains the effort to integrate and test the spacecraft bus flight model 3. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4	Propulsion Module	This element summarizes the effort to design, fabricate, assemble, and test the structure and chemical propulsion subsystems and integrate and test the propulsion module.
1.6.1.4.1	Structure	This element summarizes the effort to design, fabricate, assemble, and test the primary and secondary structures.
1.6.1.4.1.1	Primary Structure	This element contains the effort to design, fabricate, assemble, and test the primary structure. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.1.2	Secondary Structure	This element contains the effort to design, fabricate, assemble, and test the secondary structure. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.2	Chemical Propulsion	This element summarizes the effort to design, fabricate, assemble, and test the fuel and pressurant tanks, filters, valves & regulators, RCS thruster assembly, and heaters.
1.6.1.4.2.1	Fuel Tanks	This element contains the effort to design, fabricate, assemble, and test the fuel tanks. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.2.2	Pressurant Tanks	This element contains the effort to design, fabricate, assemble, and test the pressurant tanks. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.2.3	Filters, Valves & Regulators	This element contains the effort to design, fabricate, assemble, and test the filters, valves & regulators. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.2.4	RCS Thruster Assembly	This element contains the effort to design, fabricate, assemble, and test the RCS thruster assembly. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.2.5	Heaters	This element contains the effort to design, fabricate, assemble, and test the heaters. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.3	Integration & Test	This element summarizes the effort to integrate and test the engineering and flight model propulsion modules.

WBS	DESCRIPTION	WBS DICTIONARY
1.6.1.4.3.1	Propulsion Module EM I&T	This element contains the effort to integrate and test the engineering model propulsion module. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.3.2	Propulsion Module FM1 I&T	This element contains the effort to integrate and test the flight model 1 propulsion module. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.3.3	Propulsion Module FM2 I&T	This element contains the effort to integrate and test the flight model 2 propulsion module. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.4.3.4	Propulsion Module FM3 I&T	This element contains the effort to integrate and test the flight model 3 propulsion module. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.5	Spacecraft I&T (Bus & Propulsion Module)	This element summarizes the effort to integrate and test the engineering model and flight spacecraft.
1.6.1.5.1	Spacecraft EM I&T	This element contains the effort to integrate and test and pack, ship and deliver the engineering model spacecraft to observatory I&T contractor. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.5.2	Spacecraft Flight 1 I&T	This element contains the effort to integrate and test and pack, ship and deliver the flight model 1 spacecraft to observatory I&T contractor. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.5.3	Spacecraft Flight 2 I&T	This element contains the effort to integrate and test and pack, ship and deliver the flight model 2 spacecraft to observatory I&T contractor. Includes all labor, subcontracts, materials, and other direct costs.
1.6.1.5.4	Spacecraft Flight 3 I&T	This element contains the effort to integrate and test and pack, ship and deliver the flight model 3 spacecraft to observatory I&T contractor. Includes all labor, subcontracts, materials, and other direct costs.
1.6.2	Observatory Integration & Test	This element summarizes the effort to perform observatory testing on engineering and flight models.
1.6.2.1	Observatory EM Integration & Test	This element contains the effort to perform observatory test on the engineering model. Includes all labor, subcontracts, materials, and other direct costs.
1.6.2.2	Observatory Flight 1 Integration & Test	This element contains the effort to perform observatory test on flight 1 and to turnover flight 1 to constellation test. Includes all labor, subcontracts, materials, and other direct costs.
1.6.2.3	Observatory Flight 2 Integration & Test	This element contains the effort to perform observatory test on flight 2 and to turnover flight 2 to constellation test. Includes all labor, subcontracts, materials, and other direct costs.
1.6.2.4	Observatory Flight 3 Integration & Test	This element contains the effort to perform observatory test on flight 3 and to turnover flight 3 to constellation test. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.6.3	Constellation Testing	This element contains the effort to set up the constellation test facility and test the three LISA observatories in the constellation configuration. Includes all labor, subcontracts, materials, and other direct costs.
1.6.4	Final Integration (Pre-Launch)	This element contains the effort to install the payload attach fitting, perform pre-ship functional testing for the launch campaign, and pack, ship & deliver to the launch site. Includes all labor, subcontracts, materials, and other direct costs.
1.6.5	Launch Campaign	This element summarizes the effort to perform launch site operations and conduct the LISA launch.
1.6.5.1	Constellation Launch Site Operations	This element contains the effort to perform constellation launch site operations. Includes all labor, subcontracts, materials, and other direct costs.
1.6.5.2	Constellation / Launch Vehicle Operations	This element contains the effort to perform constellation/ launch vehicle operations. Includes all labor, subcontracts, materials, and other direct costs.
1.7	Mission Operations System	This element summarizes the effort to develop and maintain a support team to provide the following functions: commanding and monitoring the spacecraft subsystems, mission planning activities, mission requirements analysis, flight operations and contingency procedures development/ maintenance, spacecraft trend analysis and anomaly resolution.
1.7.1	Mission Ops Management	This element contains the effort to manage the design, development, integration, and testing of the mission operations system. Includes all labor, subcontracts, materials, and other direct costs.
1.7.2	Mission Ops System Engineering	This element contains the effort to perform system engineering of the mission operations system including management, planning, requirements definition, design, development, integration, evaluation, and testing of the hardware and software components of the mission ops system for the mission prior to launch. Includes all labor, subcontracts, materials, and other direct costs.
1.7.3	GDS Supporting Elements (Non-MOS GDS efforts)	This element contains the effort for non-GDS-specific supporting elements such as developing DSN configurations for LISA and configuring and extending the navigation tools for the LISA specific problems. Includes all labor, subcontracts, materials, and other direct costs.
1.7.4	Operations (Pre-Launch)	This element contains the effort for mission operations planning and reviews including the Mission Operations Review and the Operations Readiness Review. Includes all labor, subcontracts, materials, and other direct costs.
1.7.5	Missions Operations System V&V / Readiness Testing	This element contains the effort to perform mission operations systems validation & verification, certification and readiness testing such as End-To-End Tests, mission simulations, compatibility checks and data flows. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.8	Launch System	This element summarizes the effort to integrate with the launch vehicle and includes safety documentation, launch site procedure development, range safety support for hazardous procedure reviews, launch vehicle-to-observatory testing, launch rehearsals and launch site-to-ground control center interface testing.
1.8.1	Spacecraft-To-Launch Vehicle Interface Definition, Verification & Coordination	This element contains the effort for developing, integrating, and verifying spacecraft-to-launch vehicle interface control document. Also includes support to develop the range's operations requirements document, the missile system pre-launch safety plan (MSPSP), the launch service's mission constraints and launch countdown manuals. Includes all labor, subcontracts, materials, and other direct costs.
1.8.2	Launch Vehicle Build, Storage and Pre-Ship Operations	This element contains the effort to build, store, and perform pre-ship ops on the launch vehicle. Includes all labor, subcontracts, materials, and other direct costs.
1.8.3	Launch Services / Launch Site Operations	This element contains the effort for supporting launch services and launch site operations. Includes all labor, subcontracts, materials, and other direct costs.
1.9	Technology	This element summarizes the effort for the technology management, disturbance reduction system, interferometry measurement system, and system verification.
1.9.1	Technology Management	This element contains the effort to manage the LISA technology development effort including responding to TRIP board findings, and supporting annual independent and technology readiness reviews. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2	Disturbance Reduction System	This element summarizes the effort to perform trade studies and prototype design and testing on the gravitational reference sensor, perform trades and prototype build and testing on the thrusters, and develop algorithms and perform simulator testing on the DRS controls.
1.9.2.1	Gravitational Reference Sensor	This element summarizes the effort to perform trade studies and write reports on the housing, vacuum, caging, proof mass, proof mass control, sensing & forcing, charge control, and I&T mechanisms subsystems. This also summarizes the effort to design, fabricate, assemble, integrate and test the prototype GRS.
1.9.2.1.1	Housing Subsystem	This element contains the effort to perform trade studies and write reports for the housing subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.2	Vacuum Subsystem	This element contains the effort to perform trade studies and write reports for the vacuum subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.3	Caging Subsystem	This element contains the effort to perform trade studies and write reports for the caging subsystem. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.9.2.1.4	Proof Mass Subsystem	This element contains the effort to perform trade studies and write reports for the proof mass subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.5	Proof Mass Control Subsystem	This element contains the effort to perform trade studies and write reports for the proof mass control subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.6	Sensing & Forcing Subsystem	This element contains the effort to perform trade studies and write reports for the sensing & focusing subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.7	Charge Control Subsystem	This element contains the effort to perform trade studies and write reports for the charge control subsystem. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.8	I&T Mechanisms	This element contains the effort to perform trade studies and write reports for the I&T mechanisms. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.1.9	Prototype GRS (Lab Verified)	This element contains the effort to design, fabricate, assemble, integrate, and test the prototype GRS in a laboratory environment. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.2	Thrusters	This element summarizes the effort to develop and test a prototype emitter, perform trade studies and build and test a prototype neutralizer, develop and test prototype thruster electronics, and integrate, assemble, and test a prototype thruster.
1.9.2.2.1	Emitter	This element contains the effort to develop and test a prototype emitter and includes life testing. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.2.2	Neutralizer	This element contains the effort to perform trade studies, build and test a neutralizer prototype, and integrate with the emitter prototype. This effort also includes writing a test report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.2.3	Thruster Electronics	This element contains the effort to develop and test a prototype thruster electronics which includes writing a test report. Include all labor, subcontracts, materials, and other direct costs.
1.9.2.2.4	Prototype Thruster	This element contains the effort to integrate, assemble, and test a prototype thruster which includes writing a test report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.3	DRS Controls	This element summarizes the effort to develop control algorithms and develop and test controls simulator hardware & source code.
1.9.2.3.1	Algorithms	This element contains the effort to develop control algorithms and deliver them testing with the simulator. Includes all labor, subcontracts, materials, and other direct costs.
1.9.2.3.2	Simulator Test	This element contains the effort to develop and test controls simulator hardware and source code which includes writing a test report. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.9.3	Interferometry Measurement System	This element summarizes the effort to perform trade studies and develop breadboard and prototype lasers, develop laser/ clock noise cancellation algorithms, develop stabilization and phase meter breadboards, test the ultra stable structures, develop and build an IMS tester, and design, build, integrate, assemble and test a prototype IMS.
1.9.3.1	Laser(s)	This element contains the effort to perform trade studies and develop breadboard and prototype lasers. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.2	Laser/Clock Noise Cancellation	This element contains the effort to develop laser/ clock noise cancellation algorithms that include writing a test report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.3	Stabilization	This element contains the effort to develop stabilization breadboards. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.4	Phase Meter	This element contains the effort to develop phase meter breadboards. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.5	Ultra Stable Structures	This element contains the effort to test the ultra stable structures that include writing a test report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.6	IMS Tester	This element contains the effort to develop and build an IMS tester. Includes all labor, subcontracts, materials, and other direct costs.
1.9.3.7	Prototype IMS	This element contains the effort to design, build, integrate, assemble and test a prototype IMS which includes writing a test report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4	System Verification	This element summarizes the effort to perform integrated modeling and select and develop test bed approaches.
1.9.4.1	Integrated Modeling	This element summarizes the effort to define and develop the modeling environment, and to establish quasi-static, dynamic, phase propagation, and end-to-end models. This effort includes conducting trade studies.
1.9.4.1.1	Modeling Environment	This element contains the effort to define the requirements, conduct trade studies, and develop the modeling environment. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4.1.2	Quasi-Static Models	This element contains the effort to establish a baseline, validate requirements, conduct trade studies, and integrate the quasi-static model. This effort includes writing a final trade study report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4.1.3	Dynamic Models	This element contains the effort to establish a baseline, validate requirements, conduct trade studies, and integrate the dynamic model. This effort includes writing a final trade study report. Includes all labor, subcontracts, materials, and other direct costs.

WBS	DESCRIPTION	WBS DICTIONARY
1.9.4.1.4	Phase Propagation Models	This element contains the effort to establish a baseline, validate requirements, conduct trade studies, and integrate the phase propagation models. This effort includes writing a final trade study report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4.1.5	End-To-End Models	This element contains the effort to establish a baseline, validate requirements, conduct trade studies, and integrate the end-to-end model. This effort includes writing a final trade study report. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4.2	Test Bed Technology	This element summarizes the effort to develop test bed approaches. Includes the effort to develop LISA test beds.
1.9.4.2.1	Phase 1 - Approaches	This element contains the effort to define requirements, conduct trade studies, and select test bed approaches. Includes all labor, subcontracts, materials, and other direct costs.
1.9.4.2.2	Phase 2 - Development	This element contains the effort to develop test beds and demonstrate concepts. Includes all labor, subcontracts, materials, and other direct costs.
1.10	Mission Software	This element summarizes the effort to manage and design, develop, and test flight software, mission operations software and science operations software.
1.10.1	Software Management	This element contains the effort to develop and maintain a software management plan. Includes all labor, subcontracts, materials, and other direct costs.
1.10.2	Software Requirements Document	This element contains the effort to develop and maintain a software requirements document. Includes all labor, subcontracts, materials, and other direct costs.
1.10.3	Software Test Plan	This element contains the effort to develop and maintain a software test plan. Includes all labor, subcontracts, materials, and other direct costs.
1.10.4	Spacecraft Flight Software	This element contains the effort to define and analyze the requirements, review the software specification, and design, develop, and test the spacecraft flight software. Includes all labor, subcontracts, materials, and other direct costs.
1.10.5	Ground Data System (Mission Ops System)	This element contains the effort to write the requirements and design, build, and test the ground data system. Includes all labor, subcontracts, materials, and other direct costs.
1.10.6	Science Data System Software	This element contains the effort to write the requirements and design, build, and test the science data system software. Includes all labor, subcontracts, materials, and other direct costs.
1.10.7	IV&V	This element contains the effort to plan and coordinate the verification of the mission software. Includes all labor, subcontracts, materials, and other direct costs.

H.2 Supporting, Detailed Schedules

The LISA team has developed a comprehensive, integrated schedule for the LISA mission that:

- Identifies all work scope and is correlated to the preliminary WBS
- Incorporates critical programmatic interdependencies among the activities
- Contains engineering and planning estimates for activity durations
- Includes schedule reserves at critical points in the work flow

The integrated schedule consists of a single Microsoft Project 2000 file of over 1400 nodes that is organized by WBS. It also includes key elements such as the technology development efforts for the LISA Test Package (LTP) and ST-7 Disturbance Reduction System (DRS) that are part of ESA's SMART-2 mission.

While preliminary, the LISA integrated schedule represents an excellent starting point for further detailed planning, budgeting, and risk assessment during the Pre-Formulation and Formulation Stages.

The terms "schedule reserve," "total slack," "free slack," and "critical path" are defined below. The LISA project uses generally accepted definitions of these concepts.

Critical Path	<p>The longest sequential path through the activities in the logic network, from beginning to end, that define the earliest LISA can launch.</p> <ul style="list-style-type: none"> – Path with the longest overall duration – Path with the least amount of total slack
Slack	<p>The difference between the "early" and late "dates" of activities calculated by running a time analysis of the logic network</p> <ul style="list-style-type: none"> – <i>Free Slack</i>: the amount of duration an activity can be delayed before it impacts the early start date of an activity that succeeds it. – <i>Total Slack</i>: the amount of time an activity can be delayed from its early finish date without delaying the planned completion or end date of the project. Total slack can be positive, zero or negative
Schedule Reserve	<p>A pre-planned amount of schedule duration incorporated into the logic network at critical points and/or prior to the completion point of the project.</p>

The following detailed schedules are produced directly from the MS Project file that comprises the LISA integrated schedule. They represent the total project effort at the lowest level of the WBS and indicate the planned duration and early start and early finish dates for each activity. This appendix is divided into the following categories:

- LISA Project Phasing
- NASA Headquarters Milestones
- Major Mission Reviews
- LISA System Engineering & Integration Contractor Acquisition Cycle
- LISA/ST-7 Disturbance Reduction System (SM2)
- LISA Test Package (SM2)
- Key Formulation Stage Products

- WBS 1.1 Project Management
- WBS 1.2 System Engineering
- WBS 1.3 Mission Assurance
- WBS 1.4 Science
- WBS 1.5 Payload System
- WBS 1.6 Flight System
- WBS 1.7 Mission Operations System
- WBS 1.8 Launch System
- WBS 1.9 Technology
- WBS 1.10 Mission Software

Finally, the MS Project file from which the schedules were produced is contained on the CD that accompanies this TRIP Report.

LISA PROJECT PHASING



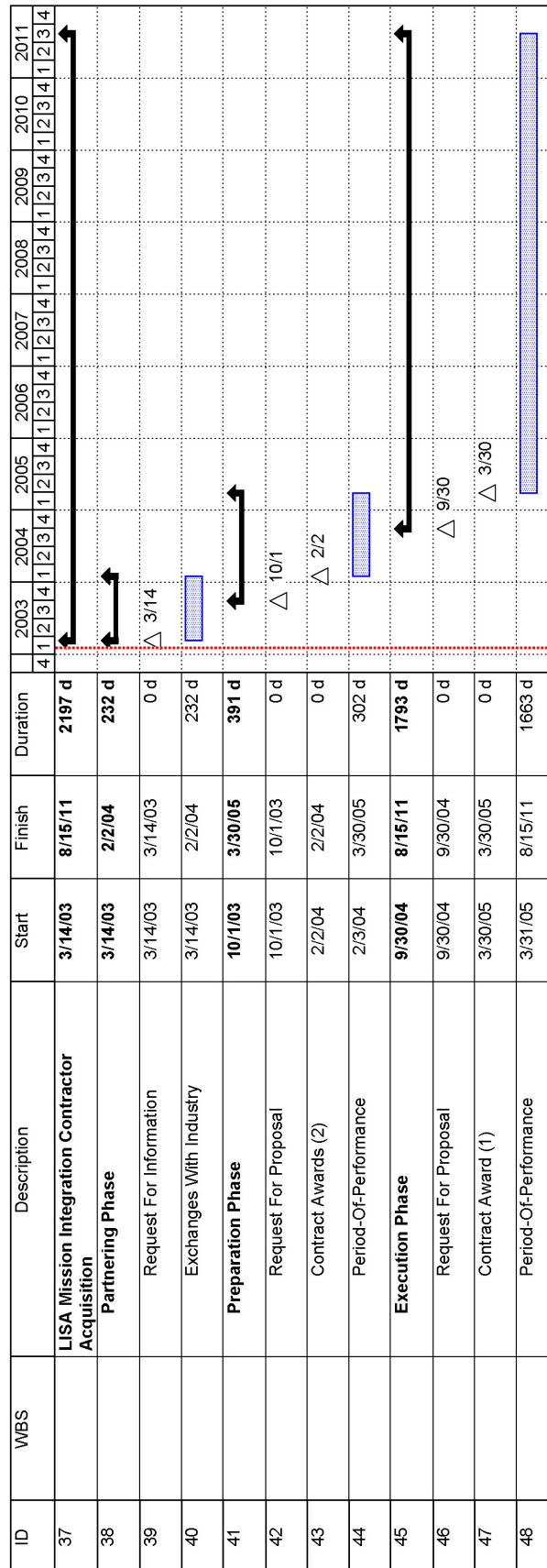
NASA HEADQUARTERS MILESTONES

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
14		NASA HQ Milestones	2/2/04	1/1/08	1020 d	4	1	2	3	4	1	2	3	4
15		Formulation Authorization Document Signed / ATP Phase A	2/2/04	2/2/04	0 d		△ 2/2							
16		Initial Confirmation Review & Confirmation Assessment / ATP Phase B	8/3/05	8/3/05	0 d			△ 8/3						
17		NASA/ESA Memorandum Of Understanding (Preliminary)	4/12/07	4/12/07	0 d					△ 4/12				
18		Non-Advocate Review	4/12/07	4/12/07	0 d					△ 4/12				
19		NASA/ESA Memorandum Of Understanding (Final)	1/1/08	1/1/08	0 d					1/1 △ ESA MOU(F)				
20		Program Commitment Agreement Approval / ATP Phase C/D	10/1/07	10/1/07	0 d					△ 10/1				

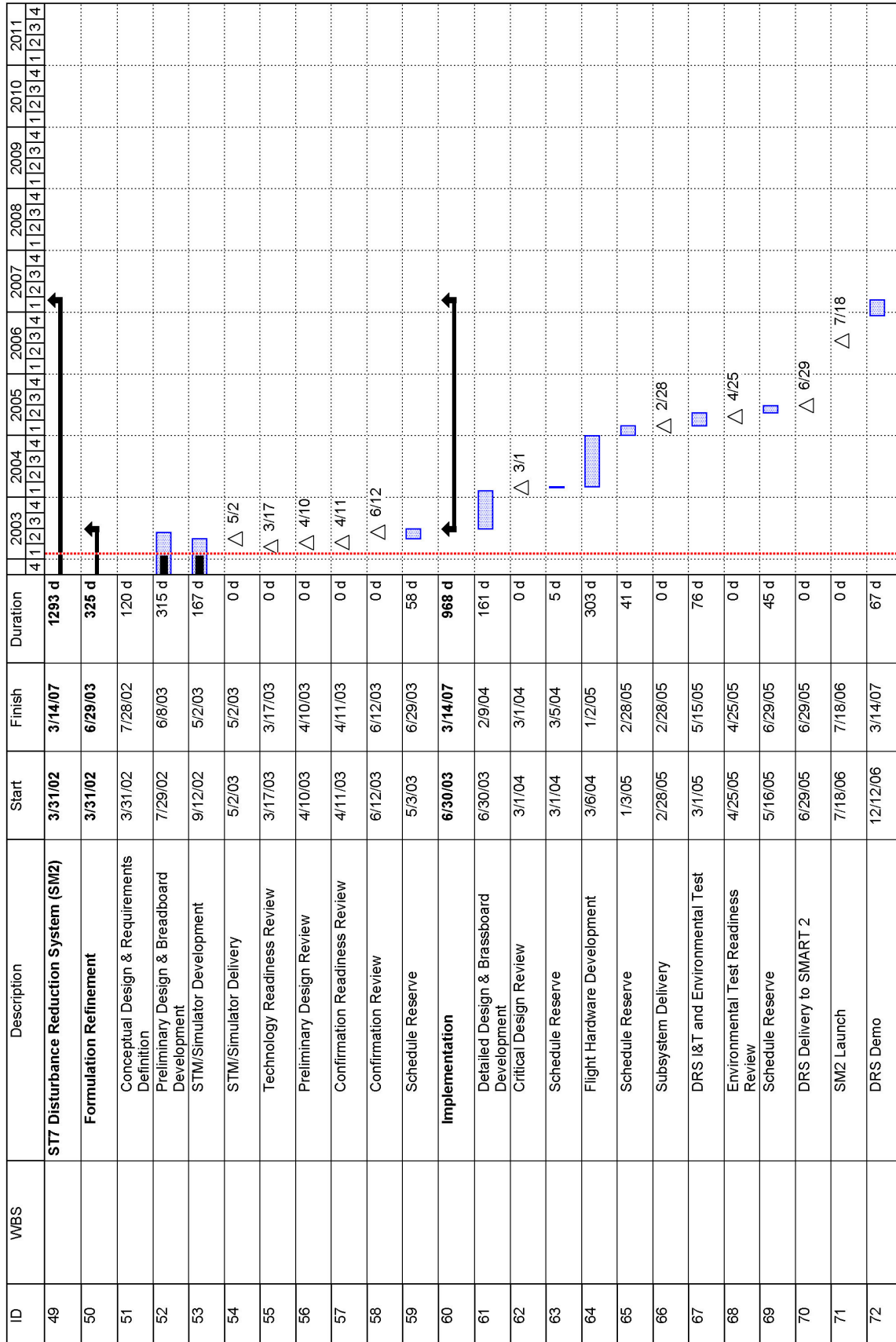
LISA MISSION REVIEWS

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
21		LISA Major Mission Reviews	12/15/03	8/14/11	2000 d	4	1	2	3	4	1	2	3	4
22		Mission Concept Review	12/15/03	12/15/03	0 d		△ 12/15							
23		Mission Definition Review	5/16/05	5/16/05	0 d			△ 5/16						
24		System Requirements Review	9/30/05	9/30/05	0 d			△ 9/30						
25		System Concept Review	12/30/05	12/30/05	0 d			△ 12/30						
26		Technology Readiness Review	11/15/06	11/15/06	0 d				△ 11/15					
27		Mission Preliminary Design Review (with Spacecraft PDR)	4/12/07	4/12/07	0 d					△ 4/12				
28		Mission Critical Design Review (with Spacecraft CDR)	3/13/08	3/13/08	0 d					△ 3/13				
29		Spacecraft Bus Flight 1 PER	2/25/09	2/25/09	0 d						△ 2/25			
30		Observatory Flight 1 PER	10/28/09	10/28/09	0 d						Obst1 PER △ 10/28			
31		Mission Operations Review	2/15/10	2/15/10	0 d							△ 2/15		
32		Operational Readiness Review	2/15/11	2/15/11	0 d								△ 2/15	
33		Constellation Pre-Ship Review	4/27/11	4/27/11	0 d								PSR △ 4/2	
34		Mission Readiness Review	7/15/11	7/15/11	0 d									△ 7/1
35		Flight Readiness Review	8/12/11	8/12/11	0 d									△ 8
36		Launch Readiness Review	8/14/11	8/14/11	0 d									△

LISA SYSTEM ENGINEERING & INTEGRATION CONTRACTOR ACQUISITION CYCLE

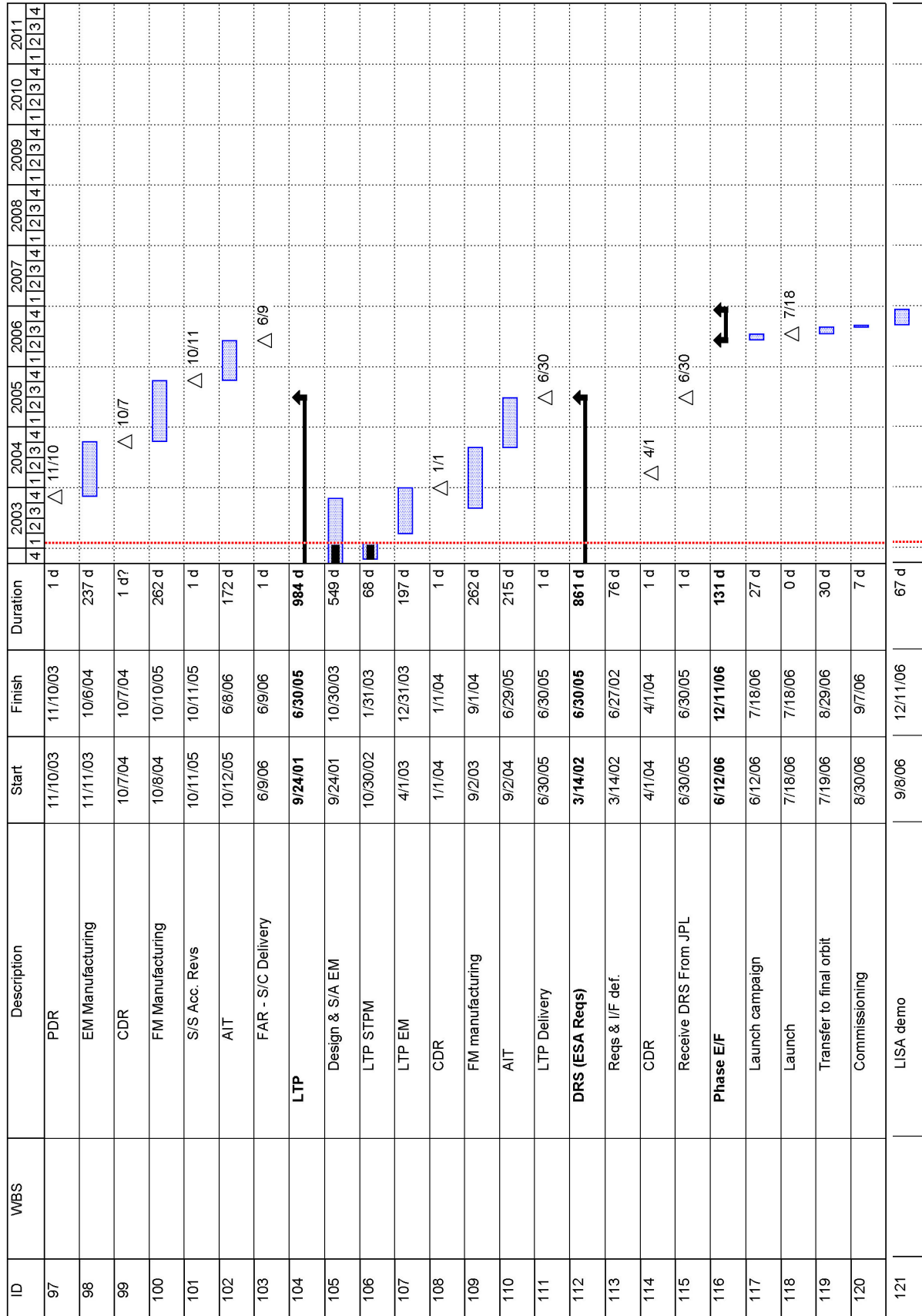


LISA ST-7 DISTURBANCE REDUCTION SYSTEM (SM2)



LISA TEST PACKAGE (SM2)

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
73		LISA Test Package (SM2)	4/10/01	12/11/06	1480 d?	4	1	2	3	4	1	2	3	4
74		SMART-2 S/C	4/10/01	6/9/06	1349 d?									
75		Definition Phase ITT	4/10/01	4/10/01	1 d									
76		Definition Phase Kick-off	9/26/01	9/26/01	1 d									
77		Definition Phase	9/27/01	7/15/02	208 d?									
78		Preliminary Mission Architecture	9/27/01	12/28/01	67 d?									
79		S/C & Technology Concept	12/31/01	3/29/02	65 d?									
80		Mission Definition & Design	4/22/02	7/12/02	60 d?									
81		SRR	7/15/02	7/15/02	1 d	7/15								
82		Implementation Phase ITT	1/24/03	6/19/03	105 d									
83		ITT Issue	1/24/03	1/24/03	1 d	1/24								
84		Bids Preparation	1/27/03	3/7/03	30 d									
85		Receive Offers	3/10/03	3/10/03	1 d									
86		Evaluation by panels	3/11/03	3/28/03	14 d									
87		Report preparation	3/31/03	4/4/03	5 d									
88		Technical Evaluation Board	4/7/03	4/7/03	1 d									
89		Report finalization	4/8/03	4/10/03	3 d									
90		Contract proposal preparation	4/11/03	4/24/03	10 d									
91		AC/IPC contr. prop. subm.	4/25/03	4/25/03	1 d									
92		AC	5/14/03	5/15/03	2 d									
93		Contract Proposal Approval by Industrial Policy Committee	6/18/03	6/19/03	2 d									
94		Implementation Phase	6/20/03	6/9/06	776 d?									
95		Implementation Phase Kick-off	6/20/03	6/20/03	1 d									
96		Design finalization	6/23/03	11/7/03	100 d									



KEY FORMULATION STAGE PRODUCTS

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
122		Key Formulation Products Summary	4/30/02	3/13/08	1532 d	4 1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
123		Project Management Formulation Products	10/1/02	8/1/07	1261 d									
124		Formulation Plan	2/3/03	9/1/03	150 d									
125		Initial (TRIP Report Submission)	2/3/03	2/3/03	0 d	2/3								
126		Update	9/1/03	9/1/03	0 d		9/1							
127		Management Agreements	10/1/02	8/1/07	1261 d									
128		NASA/ESA Definition Phase LOA	10/1/02	10/1/02	0 d	Complete								
129		GSFC/JPL Management Agreement	10/1/02	10/1/02	0 d	Complete								
130		GSFC/JPL Management Agreement - Update	5/1/03	5/1/03	0 d									
131		GSFC/JPL Management Agreement - Update	8/1/05	8/1/05	0 d									
132		GSFC/JPL Management Agreement - Update	4/2/07	4/2/07	0 d									
133		NASA/ESA Pathfinder Agreement - Initial Draft for	12/16/02	12/16/02	0 d	Complete								
134		NASA/ESA Pathfinder Agreement - Update	5/30/03	5/30/03	0 d	5/30								
135		NASA/ESA Pathfinder Agreement - Update	7/30/04	7/30/04	0 d		7/30							
136		NASA/ESA Pathfinder Agreement - Update	9/1/05	9/1/05	0 d			9/1						
137		NASA/ESA Pathfinder Agreement - Update	3/12/07	3/12/07	0 d					3/12				
138		NASA / ESA MOU - Draft	4/12/07	4/12/07	0 d					4/12				
139		JPL/ESA SMART-2 MOU	6/30/03	6/30/03	0 d	6/30								
140		Agreement with NASA HQ on Reporting Frequency & Content	8/1/07	8/1/07	0 d					8/1				
141		Project & Program Plan	5/15/03	4/12/07	1020 d									
142		Project Plan Outline - Initial	5/15/03	5/15/03	0 d	5/15								
143		Project Plan Outline - Update	7/15/04	7/15/04	0 d		7/15							
144		Project Plan - Initial	9/30/05	9/30/05	0 d				9/30					
145		Project Plan - Update	4/12/07	4/12/07	0 d					4/12				

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
146		Program Plan	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
147		Organization Approach	3/28/03	9/30/05	655 d									
148		Organizational Approach - White Paper	3/28/03	3/28/03	0 d									
149		Organizational Approach - Update For Project Plan	9/30/05	9/30/05	0 d									
150		Development Strategy	4/30/03	9/30/05	632 d									
151		Development Strategy - White Paper	4/30/03	4/30/03	0 d									
152		Development Strategy - Update For Project Plan	9/30/05	9/30/05	0 d									
153		Acquisition Strategy	5/30/03	9/30/05	610 d									
154		Acquisition Strategy - White Paper	5/30/03	5/30/03	0 d									
155		Acquisition Strategy - Update For Project Plan	9/30/05	9/30/05	0 d									
156		Work Breakdown Structure	2/3/03	9/30/05	694 d									
157		WBS - TRIP Report	2/3/03	2/3/03	0 d									
158		WBS - Update for Project Plan	9/30/05	9/30/05	0 d									
159		Budget & Life Cycle Cost Estimates	2/3/03	9/30/05	694 d									
160		Budget & LCC - Preliminary Estimate	2/3/03	2/3/03	0 d									
161		Budget & LCC - Update For Project Plan	9/30/05	9/30/05	0 d									
162		Reserves Management	3/18/03	9/30/05	663 d									
163		Reserves Mgt. Approach - White Paper	3/18/03	3/18/03	0 d									
164		Reserves Mgt. Approach - Update For Project Plan	9/30/05	9/30/05	0 d									
165		Integrated Schedule	2/3/03	9/30/05	694 d									
166		Integrated Schedule - TRIP	2/3/03	2/3/03	0 d									
167		Integrated Schedule - Update For Project Plan	9/30/05	9/30/05	0 d									
168		Independent External Review Plan	9/30/03	12/31/04	328 d									
169		Independent External Review Plan - Draft	9/30/03	9/30/03	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
170		Independent External Review Plan - Update For Project Plan	12/31/04	12/31/04	0 d	4	1	2	3	4	1	2	3	4
171		Staffing Plan	2/3/03	9/30/05	694 d	4	1	2	3	4	1	2	3	4
172		Staffing Plan - TRIP	2/3/03	2/3/03	0 d	4	1	2	3	4	1	2	3	4
173		Staffing Plan - Update For Project Plan	9/30/05	9/30/05	0 d	4	1	2	3	4	1	2	3	4
174		Data Management Plan	9/30/05	4/12/07	399 d	4	1	2	3	4	1	2	3	4
175		Initial	9/30/05	9/30/05	0 d	4	1	2	3	4	1	2	3	4
176		Update	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
177		Scientific, Technical & Economic Benefits Definition	2/27/04	9/30/05	415 d	4	1	2	3	4	1	2	3	4
178		Scientific, Technical & Economic Benefits Definition -	2/27/04	2/27/04	0 d	4	1	2	3	4	1	2	3	4
179		Scientific, Technical & Economic Benefits Definition -	9/30/05	9/30/05	0 d	4	1	2	3	4	1	2	3	4
180		Facility Requirements	12/31/03	6/30/05	391 d	4	1	2	3	4	1	2	3	4
181		Facility Rqts. - White Paper	12/31/03	12/31/03	0 d	4	1	2	3	4	1	2	3	4
182		Facility Rqts. - Update	6/30/05	6/30/05	0 d	4	1	2	3	4	1	2	3	4
183		Technology and Commercialization Plan	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
184		Descope Plan	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
185		Notices of Intent for Environmental Impact	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
186		Cancellation Review Criteria	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
187		National Environmental Policy Act Compliance Documentation - Draft	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
188		System Engineering Formulation Products	4/30/02	3/13/08	1532 d	4	1	2	3	4	1	2	3	4
189		Requirements	4/30/02	6/30/05	827 d	4	1	2	3	4	1	2	3	4
190		Level 1 Requirements Document - 1st Draft	4/30/02	4/30/02	0 d	4	1	2	3	4	1	2	3	4
191		Level 1 Requirements - TRIP Update	2/3/03	2/3/03	0 d	4	1	2	3	4	1	2	3	4
192		Level 1 Requirements Document - 2nd Draft	9/30/03	9/30/03	0 d	4	1	2	3	4	1	2	3	4
193		Level 1 Requirements Document - Final	6/30/05	6/30/05	0 d	4	1	2	3	4	1	2	3	4

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
194		System Requirements Document - 1st Draft	6/30/04	6/30/04	0 d	4	1							
195		System Requirements Document - Final	6/30/05	6/30/05	0 d									
196		System Engineering Management Plan (SEMP)	4/30/02	4/12/07	1292 d									
197		SEMP - 1st draft	4/30/02	4/30/02	0 d									
198		SEMP - 2nd draft	4/30/03	4/30/03	0 d									
199		SEMP - 3rd Draft	4/30/04	4/30/04	0 d									
200		SEMP - Update	4/12/07	4/12/07	0 d									
201		Traceability Methodology	3/31/03	6/30/05	588 d									
202		Traceability Methodology - White Paper	3/31/03	3/31/03	0 d									
203		Traceability Methodology - Update for Mission Rqts. Draft	6/30/05	6/30/05	0 d									
204		Organizational Approach	5/30/03	4/30/04	240 d									
205		Org Approach - White Paper	5/30/03	5/30/03	0 d									
206		Org Approach - Update for SEMP	4/30/04	4/30/04	0 d									
207		Reference Design	2/3/03	4/12/07	1093 d									
208		Reference Design - TRIP Update	2/3/03	2/3/03	0 d									
209		Reference Design - Update	4/30/03	4/30/03	0 d									
210		Reference Design - Update	7/31/03	7/31/03	0 d									
211		Reference Design - Update for SEMP	4/30/04	4/30/04	0 d									
212		Architecture & Design Specification - Draft	9/15/03	9/15/03	0 d									
213		Architecture & Design Specification - Update	5/16/05	5/16/05	0 d									
214		Architecture & Design Specification - Update	4/12/07	4/12/07	0 d									
215		Interface Control Documents Definition	9/30/03	4/12/07	922 d									
216		ICD Definition - Initial	9/30/03	9/30/03	0 d									
217		ICD Definition - Update for SEMP	4/30/04	4/30/04	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
218		Preliminary ICDs	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
219		Integration & Test Flow / Plan	6/30/03	3/13/08	1228 d					△ 4/12				
220		I&T Strategy/Flow - Update	6/30/03	6/30/03	0 d									
221		I&T Strategy/Flow - Update for SEMP	4/30/04	4/30/04	0 d			△ 4/30						
222		I&T Plan - Initial (PDR)	4/12/07	4/12/07	0 d					△ 4/12				
223		I&T Plan - Update (CDR)	3/13/08	3/13/08	0 d						△ 3/13			
224		EMC Plan - Initial (PDR)	4/12/07	4/12/07	0 d					△ 4/12				
225		Verification	6/30/03	4/12/07	988 d									
226		Verification Concept - White Paper	6/30/03	6/30/03	0 d									
227		Verification Matrix - Initial	6/30/04	6/30/04	0 d			△ 6/30						
228		Verification Matrix - Update	6/30/05	6/30/05	0 d				△ 6/30					
229		Verification Plan - Initial	4/12/07	4/12/07	0 d					△ 4/12				
230		End-To-End (Constellation) Testing	12/31/03	4/30/04	87 d									
231		ETE Test - White Paper	12/31/03	12/31/03	0 d					△ 12/31				
232		ETE Test - Update for SEMP	4/30/04	4/30/04	0 d			△ 4/30						
233		Primary Trade Studies	12/15/03	12/15/06	784 d									
234		Phased Array vs. High Gain Antenna (at MCR)	12/15/03	12/15/03	0 d			△ 12/15						
235		Star Tracker Mounting (at MCR)	12/15/03	12/15/03	0 d			△ 12/15						
236		Telescope Mechanism (at MCR)	12/15/03	12/15/03	0 d			△ 12/15						
237		Design Optimization to Simplify Interfaces (at MCR)	12/15/03	12/15/03	0 d			△ 12/15						
238		Location of Observatory I&T (at MCR)	12/15/03	12/15/03	0 d			△ 12/15						
239		Ranging and S/C-to-S/C Communication (at MDR)	5/16/05	5/16/05	0 d				△ 5/16					
240		Telescope vs. Laser Power (at SRR)	9/30/05	9/30/05	0 d					△ 9/30				
241		Redundancy vs. Lifetime at (SRR)	9/30/05	9/30/05	0 d					△ 9/30				

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
242		Gravity Balancing (at SRR)	9/30/05	9/30/05	0 d	4	1	2	3	4	1	2	3	4
243		Optical Bench Material Selection (at SRR)	9/30/05	9/30/05	0 d									
244		Strategy for Integration of Flight GRS (at Payload PDR)	12/15/06	12/15/06	0 d									
245		Technical Resource Allocation Process	8/29/03	4/30/04	175 d									
246		TRAP - White Paper	8/29/03	8/29/03	0 d									
247		TRAP - Update for SEMP	4/30/04	4/30/04	0 d									
248		Resource Allocations to Demonstrate Feasibility - Draft	4/30/04	4/30/04	0 d									
249		Error Budget	2/3/03	4/30/04	324 d									
250		Error Budget - TRIP Update	2/3/03	2/3/03	0 d									
251		Error Budget - Update	7/31/03	7/31/03	0 d									
252		Error Budget - Update for SEMP	4/30/04	4/30/04	0 d									
253		Risk Management Plan	2/3/03	4/12/07	1093 d									
254		Risk Mgt. Plan - TRIP	2/3/03	2/3/03	0 d									
255		Risk Mgt. Plan - Update	4/30/03	4/30/03	0 d									
256		Risk Mgt. Plan - Update	4/30/04	4/30/04	0 d									
257		Risk Mgt. Plan - Update	9/30/05	9/30/05	0 d									
258		Risk Mgt. Plan - Update	4/12/07	4/12/07	0 d									
259		Technical Documentation Approach	6/30/03	4/30/04	219 d									
260		Tech Doc Approach - White Paper	6/30/03	6/30/03	0 d									
261		Tech Doc Approach - Update for SEMP	4/30/04	4/30/04	0 d									
262		Documentation Tree	7/31/03	4/30/04	196 d									
263		Doc Tree - Initial	7/31/03	7/31/03	0 d									
264		Doc Tree - Update	4/30/04	4/30/04	0 d									
265		Equipment List	2/3/03	4/30/04	324 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
266		Equipment List - TRIP	2/3/03	2/3/03	0 d	4	1	2	3	4	1	2	3	4
267		Equipment List - Update	4/30/04	4/30/04	0 d									
268		Configuration Management Approach	6/30/03	4/12/07	988 d									
269		CM Approach - White Paper	6/30/03	6/30/03	0 d									
270		CM Approach - Update	12/31/04	12/31/04	0 d									
271		CM Plan - Initial	9/30/05	9/30/05	0 d									
272		CM Plan - Update	4/12/07	4/12/07	0 d									
273		Disposal, Re-Entry & Decommission Plan	5/16/05	4/12/07	498 d									
274		DR&D Plan - Initial (MDR)	5/16/05	5/16/05	0 d									
275		DR&D Plan - Update (PDR)	4/12/07	4/12/07	0 d									
276		Environmental Assessment (SCR)	12/30/05	12/30/05	0 d									
277		Orbital Debris Assessment - Initial (PDR)	4/12/07	4/12/07	0 d									
278		Mission Assurance Formulation Products	8/29/03	4/12/07	944 d									
279		Flight Assurance Approach	8/29/03	9/30/05	545 d									
280		Flight Assurance Approach - White Paper	8/29/03	8/29/03	0 d									
281		Flight Assurance Approach - Update For Project Plan	9/30/05	9/30/05	0 d									
282		Mission Assurance Guidelines (MAG) - Initial	4/12/07	4/12/07	0 d									
283		Mission Assurance Requirements (MAR) - Initial	4/12/07	4/12/07	0 d									
284		Safety Data Package	5/16/05	4/12/07	498 d									
285		SDP - Initial (MDR)	5/16/05	5/16/05	0 d									
286		SDP - Update (SCR)	12/30/05	12/30/05	0 d									
287		SDP - Update (PDR)	4/12/07	4/12/07	0 d									
288		System Safety Plan	12/30/05	4/12/07	334 d									
289		System Safety Plan - Initial	12/30/05	12/30/05	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
290		System Safety Plan - Update	4/12/07	4/12/07	0 d	4	1							
291		Contamination Control Plan - Initial	4/12/07	4/12/07	0 d					1	2	3	4	
292		Science Formulation Products	12/18/02	6/30/05	661 d					1	2	3	4	
293		Mission Concept	2/3/03	3/15/05	551 d					1	2	3	4	
294		Mission Concept - TRIP Update	2/3/03	2/3/03	0 d					1	2	3	4	
295		Mission Concept - Update	11/3/03	11/3/03	0 d					1	2	3	4	
296		Mission Concept - Update	3/15/05	3/15/05	0 d					1	2	3	4	
297		Science Requirements	12/18/02	4/29/05	617 d					1	2	3	4	
298		Science Rqts. - Initial	12/18/02	12/18/02	0 d					1	2	3	4	
299		Science Rqts. - TRIP	2/3/03	2/3/03	0 d					1	2	3	4	
300		Science Rqts. - Update	7/31/03	7/31/03	0 d					1	2	3	4	
301		Science Rqts. - Update	4/29/05	4/29/05	0 d					1	2	3	4	
302		Education & Public Outreach Plan	12/15/03	12/15/03	0 d					1	2	3	4	
303		Science Management	6/30/03	12/31/04	394 d					1	2	3	4	
304		Science Mgt. Approach - White Paper	6/30/03	6/30/03	0 d					1	2	3	4	
305		Science Mgt. Plan - Initial	12/31/04	12/31/04	0 d					1	2	3	4	
306		Science Data Management Plan - Draft	12/31/03	12/31/03	0 d					1	2	3	4	
307		Science Data Center Plan - Draft	12/31/03	12/31/03	0 d					1	2	3	4	
308		Science Data Mgt Plan - Update	12/31/04	12/31/04	0 d					1	2	3	4	
309		Mission Success Criteria	3/31/03	6/30/05	588 d					1	2	3	4	
310		Mission Success Criteria - Initial	3/31/03	3/31/03	0 d					1	2	3	4	
311		Mission Success Criteria - Update	6/30/04	6/30/04	0 d					1	2	3	4	
312		Mission Success Criteria - Update	6/30/05	6/30/05	0 d					1	2	3	4	
313		Minimal Mission	4/30/03	6/30/05	566 d					1	2	3	4	

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
314		Minimal Mission - Initial	4/30/03	4/30/03	0 d	4	1							
315		Minimal Mission - Update	6/30/04	6/30/04	0 d	1	2							
316		Minimal Mission - Update	6/30/05	6/30/05	0 d									
317		Astrophysics & Waveform of Sources - Initial Calculations	12/31/03	12/31/03	0 d									
318		Initial Data Analysis Methods for Modeling	12/15/03	12/15/03	0 d									
319		Payload System Formulation Products	2/3/03	9/30/05	694 d									
320		Payload Concept	2/3/03	4/30/04	324 d									
321		P/L Concept - TRIP Update	2/3/03	2/3/03	0 d									
322		P/L Concept - Update for SEMP	4/30/04	4/30/04	0 d									
323		Flight Segment (Payload) Performance Requirements & Metrics	2/28/03	9/30/05	675 d									
324		Flight Segment (Payload) Performance Rqts. & Metrics - Initial	2/28/03	2/28/03	0 d									
325		Flight Segment (Payload) Performance Rqts. & Metrics - Update	9/30/05	9/30/05	0 d									
326		Flight System Formulation Products	2/3/03	9/30/05	694 d									
327		Spacecraft Concept	2/3/03	4/30/04	324 d									
328		S/C Concept - TRIP Update	2/3/03	2/3/03	0 d									
329		S/C Concept - Update for SEMP	4/30/04	4/30/04	0 d									
330		Flight Segment Performance Requirements & Metrics	2/28/03	9/30/05	675 d									
331		Flight Segment Performance Rqts. & Metrics - Initial	2/28/03	2/28/03	0 d									
332		Flight Segment Performance Rqts. & Metrics Update	9/30/05	9/30/05	0 d									
333		Mission Operations System Formulation Products	2/28/03	4/12/07	1074 d									
334		Operations Concept	9/15/03	4/12/07	933 d									
335		Ops Concept Definition - Initial	9/15/03	9/15/03	0 d									
336		Ops Concept Definition - Update	5/16/05	5/16/05	0 d									
337		Ops Concept Definition - Update	4/12/07	4/12/07	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
338		Organizational Approach	5/1/03	5/16/05	532 d	4	1	2	3	4	1	2	3	4
339		Org Approach - White Paper	5/1/03	5/1/03	0 d	△	5/1							
340		Org Approach - Update	5/16/05	5/16/05	0 d			△	5/16					
341		Driving Requirements	2/28/03	5/16/05	576 d	2	28							
342		Driving Rqts. - White Paper	2/28/03	2/28/03	0 d	△	2/28							
343		Driving Rqts. - Update	5/16/05	5/16/05	0 d			△	5/16					
344		Orbital Parameters	3/31/03	5/16/05	555 d	3	31							
345		Orbital Parameters - Initial	3/31/03	3/31/03	0 d	△	3/31							
346		Orbital Parameters - Update	5/16/05	5/16/05	0 d			△	5/16					
347		Communications Strategy	6/30/03	5/16/05	490 d	6	30							
348		Comm Strategy - White Paper	6/30/03	6/30/03	0 d	△	6/30							
349		Comm Strategy - Update	5/16/05	5/16/05	0 d			△	5/16					
350		Data Collection Approach	9/15/03	5/16/05	435 d	9	15							
351		Data Collection Approach - White Paper	9/15/03	9/15/03	0 d	△	9/15							
352		Data Collection Approach - Update	5/16/05	5/16/05	0 d			△	5/16					
353		Data Policy	9/15/03	5/16/05	435 d	9	15							
354		Data Policy - Initial	9/15/03	9/15/03	0 d	△	9/15							
355		Data Policy - Update	5/16/05	5/16/05	0 d			△	5/16					
356		Data Reduction Approach	9/15/03	5/16/05	435 d	9	15							
357		Data Reduction Approach - White Paper	9/15/03	9/15/03	0 d	△	9/15							
358		Data Reduction Approach - Update for Mission Ops Rqts	5/16/05	5/16/05	0 d			△	5/16					
359		System Sizing	9/15/03	12/22/05	593 d	9	15							
360		System Sizing - White Paper	9/15/03	9/15/03	0 d	△	9/15							
361		System Sizing - Update	12/22/05	12/22/05	0 d				△	12/22				

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
362		Ground Segment Performance Rqts. & Metrics	12/15/03	5/16/05	370 d	4	1	2	3	4	1	2	3	4
363		Ground Segment Performance Rqts. & Metrics - Initial	12/15/03	12/15/03	0 d		Δ 12/15							
364		Ground Segment Performance Rqts. & Metrics - Update	5/16/05	5/16/05	0 d			Δ 5/16						
365		Launch System Formulation Products	6/30/03	5/16/05	490 d									
366		Launch Vehicle Options	6/30/03	4/30/04	219 d									
367		LV Options - White Paper	6/30/03	6/30/03	0 d		Δ 6/30							
368		LV Options - Initial for SEMP	4/30/04	4/30/04	0 d		Δ 4/30							
369		Launch Segment Performance Requirements & Metrics	12/22/03	5/16/05	365 d									
370		Launch Segment Performance Rqts. & Metrics - Initial	12/22/03	12/22/03	0 d		Δ 12/22							
371		Launch Segment Performance Rqts. & Metrics Update	5/16/05	5/16/05	0 d			Δ 5/16						
372		Technology Development Formulation Products	10/1/02	6/30/05	717 d									
373		Description/Rationale for Required Technologies	2/28/03	1/31/05	501 d									
374		Description/Rationale - Draft for TDIP	2/28/03	2/28/03	0 d		Δ 2/28							
375		Description/Rationale - Update for TDIP Update	1/31/05	1/31/05	0 d			Δ 1/31						
376		Alignment With Enterprise Roadmaps	2/28/03	1/31/05	501 d									
377		AWER - Draft for TDIP	2/28/03	2/28/03	0 d		Δ 2/28							
378		AWER - Update for TDIP Update	1/31/05	1/31/05	0 d			Δ 1/31						
379		Definition of Technology Products	2/28/03	1/31/05	501 d									
380		Do TP - Draft for TDIP	2/28/03	2/28/03	0 d		Δ 2/28							
381		Do TP - Update for TDIP Update	1/31/05	1/31/05	0 d			Δ 1/31						
382		Test Bed Definition	2/28/03	1/31/05	501 d									
383		Test Bed Definition - Draft for TDIP	2/28/03	2/28/03	0 d		Δ 2/28							
384		Test Bed Definition - Update for TDIP Update	1/31/05	1/31/05	0 d			Δ 1/31						
385		Maturity Milestones/Investment Plan	2/28/03	1/31/05	501 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
386		MMIP - Draft for TDIP	2/28/03	2/28/03	0 d	4	1	2	3	4	1	2	3	4
387		MMIP - Update for TDIP Update	1/31/05	1/31/05	0 d			1	2	3	4	1	2	3
388		Integrated Modeling Approach	10/1/02	1/31/05	609 d									
389		IM Approach - Draft for TDIP	10/1/02	10/1/02	0 d									
390		IM Approach - Update for TDIP Update	1/31/05	1/31/05	0 d			1	2	3	4	1	2	3
391		Role of Technology Validation Mission	3/31/03	1/31/05	480 d									
392		Role of TVM - Draft	3/31/03	3/31/03	0 d									
393		Role of TVM - Update for TDIP Update	1/31/05	1/31/05	0 d			1	2	3	4	1	2	3
394		Independent Technology Readiness Assessment	4/30/03	6/30/05	566 d									
395		TRIP Report Findings	4/30/03	4/30/03	0 d									
396		2004 Independent Tech Review	6/30/04	6/30/04	0 d									
397		2005 Independent Tech Review	6/30/05	6/30/05	0 d									
398		Mission Software Formulation Products	4/30/03	3/2/07	1002 d									
399		Software Architecture/Developmental	4/30/03	4/30/04	262 d									
400		S/W Architecture - White Paper	4/30/03	4/30/03	0 d									
401		S/W Architecture - Update for SEMP	4/30/04	4/30/04	0 d									
402		Role of IV&V	8/29/03	4/30/04	175 d									
403		IV&V Role - White Paper	8/29/03	8/29/03	0 d									
404		IV&V Role - Update for SEMP	4/30/04	4/30/04	0 d									
405		Software Management Plan	5/16/05	3/2/07	469 d									
406		Software Management Plan - Initial (MDR)	5/16/05	5/16/05	0 d									
407		Software Management Plan - Update (FSW PDR)	3/2/07	3/2/07	0 d									
408		Software Requirements Document	5/26/06	3/2/07	200 d									
409		SRD - Initial (FSW SSR)	5/26/06	5/26/06	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
410		SRD - Update (FSW PDR)	3/2/07	3/2/07	0 d	4	1	2	3	4	1	2	3	4
411		Software Test Plan	3/2/07	3/2/07	0 d					△	3/2			
412		Software Test Plan - Initial (FSW PDR)	3/2/07	3/2/07	0 d					△	3/2			

LISA PROJECT MANAGEMENT WBS 1.1

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
413	1.1	Project Management	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
414	1.1.1	Project Management	10/1/02	8/15/11	2315 d									
415	1.1.2	Project Scientist	10/1/02	8/15/11	2315 d									
416	1.1.3	Business Management	10/1/02	8/15/11	2315 d									
417	1.1.4	Scheduling	10/1/02	8/15/11	2315 d									
418	1.1.5	Procurement Management	10/1/02	8/15/11	2315 d									
419	1.1.6	Project Support	10/1/02	8/15/11	2315 d									

SYSTEM ENGINEERING WBS 1.2

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
420	1.2	System Engineering	4/30/02	8/15/11	2425 d	4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4								
421	1.2.1	System Engineering Management	4/30/02	8/15/11	2425 d									
422	1.2.1.1	System Engineering Management Plan (SEMP)	4/30/02	4/12/07	1292 d									
423	1.2.1.1.1	SEMP - 1st draft	4/30/02	4/30/02	0 d	30								
424	1.2.1.1.2	SEMP - 2nd draft	4/30/03	4/30/03	0 d									
425	1.2.1.1.3	SEMP - 3rd Draft	4/30/04	4/30/04	0 d									
426	1.2.1.1.4	SEMP - Update	4/12/07	4/12/07	0 d									
427	1.2.1.2	System Architect Team	12/2/02	8/15/11	2271 d									
428	1.2.1.3	Major Reviews (see LISA Major Mission Reviews)	12/15/03	8/12/11	2000 d									
429	1.2.1.4	Communications & SE Tools	10/1/02	8/15/11	2315 d									
430	1.2.1.4.1	Quarterly TIMS & Science Engineering Workshops	10/1/02	8/15/11	2315 d									
431	1.2.1.4.2	Launch VSDE	12/31/02	12/31/02	0 d									
432	1.2.2	Requirements	4/30/02	8/15/11	2425 d									
433	1.2.2.1	Requirements Definition	4/30/02	6/30/05	827 d									
434	1.2.2.1.1	Level 1 Requirements Document - 1st Draft	4/30/02	4/30/02	0 d	30								
435	1.2.2.1.2	Level 1 Requirements Document - 2nd Draft	9/30/03	9/30/03	0 d									
436	1.2.2.1.3	Level 1 Requirements Document - Final	6/30/05	6/30/05	0 d									
437	1.2.2.1.4	System Requirements Document - 1st Draft	6/30/04	6/30/04	0 d									
438	1.2.2.1.5	System Requirements Document - Final	6/30/05	6/30/05	0 d									
439	1.2.2.2	Requirements Database	6/30/05	8/15/11	1598 d									
440	1.2.2.2.1	Develop Requirements Database	6/30/05	12/15/05	121 d									
441	1.2.2.2.2	Database Maintenance	12/16/05	8/15/11	1477 d									
442	1.2.2.3	Disposal, Re-Entry & Decommission Plan	5/16/05	3/13/08	738 d									
443	1.2.2.3.1	DR&D Plan - Initial (MDR)	5/16/05	5/16/05	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
444	1.2.2.3.2	DR&D Plan - Update (PDR)	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
445	1.2.2.3.3	DR&D Plan - Update (CDR)	3/13/08	3/13/08	0 d					Δ 4/12				
446	1.2.2.4	Environmental Assessment (SCR)	12/30/05	12/30/05	0 d			Δ 12/30			Δ 3/13			
447	1.2.2.5	Orbital Debris Assessment	4/12/07	3/13/08	240 d					↔	↔			
448	1.2.2.5.1	Orbital Debris Assessment - Initial (PDR)	4/12/07	4/12/07	0 d					Δ 4/12				
449	1.2.2.5.2	Orbital Debris Assessment - Update (CDR)	3/13/08	3/13/08	0 d						Δ 3/13			
450	1.2.3	System Validation & Verification	6/30/04	8/15/11	1859 d									
451	1.2.3.1	Verification Matrix - Initial	6/30/04	6/30/04	0 d			Δ 6/30						
452	1.2.3.2	Verification Matrix - Update	6/30/05	6/30/05	0 d			Δ 6/30						
453	1.2.3.3	Verification Plan - Initial (PDR)	4/12/07	4/12/07	0 d					Δ 4/12				
454	1.2.3.4	Verification Plan - Update (CDR)	3/13/08	3/13/08	0 d						Δ 3/13			
455	1.2.3.5	Verification	4/14/09	8/15/11	610 d									
456	1.2.4	Operations Concept Definition	10/1/02	4/12/07	1183 d									
457	1.2.4.1	Ops Concept Trade Studies / Definition	10/1/02	4/12/07	1183 d									
458	1.2.4.2	Ops Concept Definition - Draft #1	9/15/03	9/15/03	0 d			Δ 9/15						
459	1.2.4.3	Ops Concept Definition - Draft #2	5/16/05	5/16/05	0 d			Δ 5/16						
460	1.2.4.4	Ops Concept Definition - Update (PDR)	4/12/07	4/12/07	0 d					Δ 4/12				
461	1.2.5	System Architecture & Design	10/1/02	8/15/11	2315 d									
462	1.2.5.1	System Architecture / Trade Studies	10/1/02	4/12/07	1183 d									
463	1.2.5.1.1	Primary Trade Studies	10/1/02	4/12/07	1183 d									
464	1.2.5.1.1.1	Trade Studies	10/1/02	4/12/07	1183 d									
465	1.2.5.1.1.2	Phased Array vs. High Gain Antenna (at MCR)	12/15/03	12/15/03	0 d			Δ 12/15						
466	1.2.5.1.1.3	Star Tracker Mounting (at MCR)	12/15/03	12/15/03	0 d			Δ 12/15						
467	1.2.5.1.1.4	Telescope Mechanism (at MCR)	12/15/03	12/15/03	0 d			Δ 12/15						

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
468	1.2.5.1.1.5	Design Optimization to Simplify Interfaces (at I&T (at MCR)	12/15/03	12/15/03	0 d	4	1							
469	1.2.5.1.1.6	Location of Observatory	12/15/03	12/15/03	0 d	1	2							
470	1.2.5.1.1.7	Ranging and S/C-to-S/C Communication (at MDR)	5/16/05	5/16/05	0 d									
471	1.2.5.1.1.8	Telescope vs. Laser Power (at SRR)	9/30/05	9/30/05	0 d									
472	1.2.5.1.1.9	Redundancy vs. Lifetime at (SRR)	9/30/05	9/30/05	0 d									
473	1.2.5.1.1.10	Gravity Balancing (at SRR)	9/30/05	9/30/05	0 d									
474	1.2.5.1.1.11	Optical Bench Material Selection (at SRR)	9/30/05	9/30/05	0 d									
475	1.2.5.1.1.12	Strategy for Integration of Flight GRS (at Payload)	12/15/06	12/15/06	0 d									
476	1.2.5.2	Architecture & Design Specification - Draft	9/15/03	9/15/03	0 d									
477	1.2.5.3	Architecture & Design Specification - Update	5/16/05	5/16/05	0 d									
478	1.2.5.4	Architecture & Design Specification - Update	4/12/07	4/12/07	0 d									
479	1.2.5.5	Integrated Modeling (Post-Technology Development)	5/1/07	8/15/11	1120 d									
480	1.2.6	Interfaces and ICDs	9/15/03	8/11/08	1281 d									
481	1.2.6.1	ICD Development	9/15/03	8/11/08	1281 d									
482	1.2.6.2	Preliminary ICDs (PDR)	4/12/07	4/12/07	0 d									
483	1.2.6.3	ICD Updates (CDR)	3/13/08	3/13/08	0 d									
484	1.2.7	Software System Engineering	10/1/02	8/15/11	2315 d									
485	1.2.7.1	Software System Management	12/2/02	8/15/11	2271 d									
486	1.2.7.2	Software Architecture	10/1/02	8/15/11	2315 d									
487	1.2.7.3	IV&V	2/4/08	1/19/10	512 d									
488	1.2.8	Configuration Management	6/30/03	8/15/11	2121 d									
489	1.2.8.1	CM Approach - White Paper	6/30/03	6/30/03	0 d									
490	1.2.8.2	CM Approach - Update	12/31/04	12/31/04	0 d									
491	1.2.8.3	CM Plan - Initial	9/30/05	9/30/05	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
492	1.2.8.4	CM Plan - Update	4/12/07	4/12/07	0 d	4	1	2	3	4	1	2	3	4
493	1.2.8.5	Configuration Control Board	9/30/05	8/15/11	1532 d									
494	1.2.9	Risk Management	2/3/03	4/12/07	1093 d									
495	1.2.9.1	Risk Mgt. Plan - TRIP	2/3/03	2/3/03	0 d									
496	1.2.9.2	Risk Mgt. Plan - Update	4/30/03	4/30/03	0 d									
497	1.2.9.3	Risk Mgt. Plan - Update	4/30/04	4/30/04	0 d									
498	1.2.9.4	Risk Mgt. Plan - Update	9/30/05	9/30/05	0 d									
499	1.2.9.5	Risk Mgt. Plan - Update	4/12/07	4/12/07	0 d									
500	1.2.10	System Integration & Test (Support)	7/3/06	8/15/11	1336 d									
501	1.2.10.1	Observatory Integration	3/31/09	12/10/10	444 d									
502	1.2.10.2	Integration & Test Plan	4/12/07	3/13/08	240 d									
503	1.2.10.2.1	I&T Plan - Initial (PDR)	4/12/07	4/12/07	0 d									
504	1.2.10.2.2	I&T Plan - Update (CDR)	3/13/08	3/13/08	0 d									
505	1.2.10.3	EMC Plan	4/12/07	3/13/08	240 d									
506	1.2.10.3.1	EMC Plan - Initial (PDR)	4/12/07	4/12/07	0 d									
507	1.2.10.3.2	EMC Plan - Update (CDR)	3/13/08	3/13/08	0 d									
508	1.2.10.4	System Level Testing	7/3/06	8/15/11	1336 d									
509	1.2.10.4.1	Testbed Operations	7/3/06	8/15/11	1336 d									
510	1.2.10.4.2	System Performance Testing	3/22/10	10/19/10	152 d									
511	1.2.10.4.3	Environmental Testing	9/6/10	12/10/10	70 d									
512	1.2.10.4.4	Launch System Integration & Test	5/5/11	8/15/11	73 d									

MISSION ASSURANCE WBS 1.3

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
513	1.3	Mission Assurance	8/29/03	8/15/11	2077 d	4 1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4	1 1 2 3 4
514	1.3.1	Mission Assurance Management	8/29/03	3/13/08	1184 d									
515	1.3.1.1	Flight Assurance Approach	8/29/03	9/30/05	545 d									
516	1.3.1.1.1	Flight Assurance Approach - White Paper	8/29/03	8/29/03	0 d									
517	1.3.1.1.2	Flight Assurance Approach - Update For Project Plan	9/30/05	9/30/05	0 d									
518	1.3.1.2	Mission Assurance Guidelines (MAG)	4/12/07	3/13/08	240 d									
519	1.3.1.2.1	MAG - Initial (PDR)	4/12/07	4/12/07	0 d									
520	1.3.1.2.2	MAG - Update (CDR)	3/13/08	3/13/08	0 d									
521	1.3.1.3	Mission Assurance Requirements Document	4/12/07	3/13/08	240 d									
522	1.3.1.3.1	MAR - Initial (PDR)	4/12/07	4/12/07	0 d									
523	1.3.1.3.2	MAR - Update (CDR)	3/13/08	3/13/08	0 d									
524	1.3.2	System Safety	5/16/05	8/12/11	1629 d									
525	1.3.2.1	Safety Data Package	5/16/05	8/12/11	1629 d									
526	1.3.2.1.1	SDP - Initial (MDR)	5/16/05	5/16/05	0 d									
527	1.3.2.1.2	SDP - Update (SCR)	12/30/05	12/30/05	0 d									
528	1.3.2.1.3	SDP - Update (PDR)	4/12/07	4/12/07	0 d									
529	1.3.2.1.4	SDP - Update (CDR)	3/13/08	3/13/08	0 d									
530	1.3.2.1.5	SDP - Update (FRR)	8/12/11	8/12/11	0 d									
531	1.3.2.2	System Safety Plan	12/30/05	4/12/07	334 d									
532	1.3.2.2.1	SSP - Initial (SCR)	12/30/05	12/30/05	0 d									
533	1.3.2.2.2	SSP - Update (PDR)	4/12/07	4/12/07	0 d									
534	1.3.3	Contamination Control	4/12/07	3/13/08	240 d									
535	1.3.3.1	Contamination Control Plan	4/12/07	3/13/08	240 d									
536	1.3.3.1.1	CCP - Initial (PDR)	4/12/07	4/12/07	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
537	1.3.3.1.2	CCP - Update (CDR)	3/13/08	3/13/08	0 d	4	1	2	3	4	1	2	3	4
538	1.3.4	IV&V	2/4/08	1/19/10	512 d						△	3/13		
539	1.3.5	Quality Assurance	8/29/03	8/15/11	2077 d									

SCIENCE WBS 1.4

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
540	1.4	Science	10/1/02	8/15/11	2315 d	4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4								
541	1.4.1	Mission Science Office	10/1/02	8/15/11	2315 d									
542	1.4.1.1	Mission Scientist	10/1/02	8/15/11	2315 d									
543	1.4.1.2	Science Team	10/1/02	8/15/11	2315 d									
544	1.4.1.3	Science Management Plan	6/30/03	9/30/05	589 d									
545	1.4.1.3.1	Science Management Approach - White Paper	6/30/03	6/30/03	0 d									
546	1.4.1.3.2	Science Management Plan - Initial	5/16/05	5/16/05	0 d									
547	1.4.1.3.3	Science Management Plan - Update	9/30/05	9/30/05	0 d									
548	1.4.1.4	Science Requirements	12/18/02	4/29/05	617 d									
549	1.4.1.4.1	Science Rqts. - Initial	12/18/02	12/18/02	0 d									
550	1.4.1.4.2	Science Rqts. - TRIP Update	2/3/03	2/3/03	0 d									
551	1.4.1.4.3	Science Rqts. - Update	7/31/03	7/31/03	0 d									
552	1.4.1.4.4	Science Rqts. - Update	4/29/05	4/29/05	0 d									
553	1.4.1.5	Astrophysics & Waveform of Sources	12/31/03	8/15/11	1989 d									
554	1.4.1.5.1	Initial Calculations	12/31/03	12/31/03	0 d									
555	1.4.1.5.2	Continuing Updates	12/31/03	8/15/11	1989 d									
556	1.4.1.6	Data Analysis Methods	12/15/03	8/15/11	2001 d									
557	1.4.1.6.1	Initial Methods for Modeling	12/15/03	12/15/03	0 d									
558	1.4.1.6.2	Methods Refinement	12/15/03	8/15/11	2001 d									
559	1.4.1.7	Science Community Interface	2/3/04	8/15/11	1965 d									
560	1.4.2	Science Operations	3/22/10	8/15/11	366 d									
561	1.4.2.1	Operations Support	3/22/10	6/22/11	328 d									
562	1.4.2.2	Scientific Performance Characterization	3/22/10	8/15/11	366 d									
563	1.4.3	Science Data Support	6/1/03	6/22/11	2103 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
564	1.4.3.1	Data Analysis			0 d	4	1	2	3	4	1	2	3	4
565	1.4.3.2	Data Archiving & Distribution	12/31/03	6/22/11	1951 d									
566	1.4.3.2.1	Science Data Mgt Plan - Draft	12/31/03	12/31/03	0 d									
567	1.4.3.2.2	Science Data Mgt Plan - Update	12/31/04	12/31/04	0 d									
568	1.4.3.2.3	Data Archiving & Distribution	3/22/10	6/22/11	328 d									
569	1.4.3.3	Participating Scientists			0 d									
570	1.4.4	Education & Public Outreach	10/1/02	8/15/11	2315 d									

PAYLOAD SYSTEM WBS 1.5

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
571	1.5	Payload System	5/16/05	12/13/10	1456 d	4	1	2	3	4	1	2	3	4
572	1.5.1	Payload System Engineering / Management	5/16/05	12/13/10	1456 d									
573	1.5.1.1	Rqts., Interfaces, Architecture, Conceptual Design, Trades, etc.	5/16/05	12/13/10	1456 d									
574	1.5.1.2	Payload Preliminary Design Review	12/15/06	12/15/06	0 d									
575	1.5.1.3	Payload Critical Design Review	2/1/08	2/1/08	0 d									
576	1.5.2	Optical Assembly	9/30/05	5/1/09	936 d									
577	1.5.2.1	Optical Bench Assembly	9/30/05	8/1/08	741 d									
578	1.5.2.1.1	Design	9/30/05	1/17/08	600 d									
579	1.5.2.1.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
580	1.5.2.1.1.2	PDR	11/23/06	11/23/06	0 d									
581	1.5.2.1.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
582	1.5.2.1.1.4	CDR	1/17/08	1/17/08	0 d									
583	1.5.2.1.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
584	1.5.2.1.2.1	Optical Bench	2/4/08	8/1/08	130 d									
585	1.5.2.1.2.2	Dummy Gravitational Sensor	2/4/08	8/1/08	130 d									
586	1.5.2.1.2.3	Fiber Positioner	2/4/08	8/1/08	130 d									
587	1.5.2.1.2.4	Optics	2/4/08	8/1/08	130 d									
588	1.5.2.1.2.5	Laser Stabilization Cavity	2/4/08	8/1/08	130 d									
589	1.5.2.1.2.6	Pre-Mounting For CCD & Diodes	2/4/08	8/1/08	130 d									
590	1.5.2.1.2.7	Integration Fixture	2/4/08	8/1/08	130 d									
591	1.5.2.2	CCD Sensor	9/30/05	2/6/09	876 d									
592	1.5.2.2.1	Design	9/30/05	1/17/08	600 d									
593	1.5.2.2.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
594	1.5.2.2.1.2	PDR	11/23/06	11/23/06	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
						4	1	2	3	4	1	2	3	4
595	1.5.2.2.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
596	1.5.2.2.1.4	CDR	1/17/08	1/17/08	0 d									
597	1.5.2.2.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
598	1.5.2.2.2.1	CCD	2/4/08	8/1/08	130 d									
599	1.5.2.2.2.2	CCD Electronics	2/4/08	8/1/08	130 d									
600	1.5.2.2.3	Integration & Test	1/18/08	2/6/09	276 d									
601	1.5.2.2.3.1	CCD Sensor EM I&T	1/18/08	4/10/08	60 d									
602	1.5.2.2.3.2	CCD Sensor FM1 I&T	8/4/08	10/10/08	50 d									
603	1.5.2.2.3.3	CCD Sensor FM2 I&T	10/13/08	12/12/08	45 d									
604	1.5.2.2.3.4	CCD Sensor FM3 I&T	12/15/08	2/6/09	40 d									
605	1.5.2.3	Phase Detector	9/30/05	2/6/09	876 d									
606	1.5.2.3.1	Design	9/30/05	1/17/08	600 d									
607	1.5.2.3.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
608	1.5.2.3.1.2	PDR	11/23/06	11/23/06	0 d									
609	1.5.2.3.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
610	1.5.2.3.1.4	CDR	1/17/08	1/17/08	0 d									
611	1.5.2.3.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
612	1.5.2.3.2.1	Diodes & Hardware	2/4/08	8/1/08	130 d									
613	1.5.2.3.2.2	Pre-Amplifiers	2/4/08	8/1/08	130 d									
614	1.5.2.3.2.3	Phase Readout Electronics	2/4/08	8/1/08	130 d									
615	1.5.2.3.2.4	Ultra Stable Oscillator	2/4/08	8/1/08	130 d									
616	1.5.2.3.3	Integration & Test	1/18/08	2/6/09	276 d									
617	1.5.2.3.3.1	Phase Detector EM I&T	1/18/08	4/10/08	60 d									
618	1.5.2.3.3.2	Phase Detector FM1 I&T	8/4/08	10/10/08	50 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
619	1.5.2.3.3.3	Phase Detector FM2 I&T	10/13/08	12/12/08	45 d	4	1	2	3	4	1	2	3	4
620	1.5.2.3.3.4	Phase Detector FM3 I&T	12/15/08	2/6/09	40 d									
621	1.5.2.4	Laser	9/30/05	3/20/09	906 d									
622	1.5.2.4.1	Design	9/30/05	1/17/08	600 d									
623	1.5.2.4.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
624	1.5.2.4.1.2	PDR	11/23/06	11/23/06	0 d									
625	1.5.2.4.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
626	1.5.2.4.1.4	CDR	1/17/08	1/17/08	0 d									
627	1.5.2.4.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
628	1.5.2.4.2.1	Fiber Delivery System	2/4/08	8/1/08	130 d									
629	1.5.2.4.2.2	Laser Stabilization Electronics	2/4/08	8/1/08	130 d									
630	1.5.2.4.2.3	Laser	2/4/08	8/1/08	130 d									
631	1.5.2.4.2.4	Phase Modulator	2/4/08	8/1/08	130 d									
632	1.5.2.4.2.5	Phase Modulator Electronics & Data I/F	2/4/08	8/1/08	130 d									
633	1.5.2.4.3	Integration & Test	1/18/08	3/20/09	306 d									
634	1.5.2.4.3.1	Laser EM I&T	1/18/08	4/17/08	65 d									
635	1.5.2.4.3.2	Laser FM1 I&T	8/4/08	10/24/08	60 d									
636	1.5.2.4.3.3	Laser FM2 I&T	10/27/08	1/9/09	55 d									
637	1.5.2.4.3.4	Laser FM3 I&T	1/12/09	3/20/09	50 d									
638	1.5.2.5	Optical Assembly Structure	9/30/05	9/12/08	771 d									
639	1.5.2.5.1	Design	9/30/05	1/17/08	600 d									
640	1.5.2.5.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
641	1.5.2.5.1.2	PDR	11/23/06	11/23/06	0 d									
642	1.5.2.5.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
643	1.5.2.5.1.4	CDR	1/17/08	1/17/08	0 d	4	1	2	3	4	1	2	3	4
644	1.5.2.5.2	Flight Fab, Assembly & Test	2/4/08	9/12/08	160 d						1	2	3	4
645	1.5.2.6	Star Tracker	9/30/05	1/17/08	811 d						1	2	3	4
646	1.5.2.6.1	Design	9/30/05	1/17/08	600 d						1	2	3	4
647	1.5.2.6.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d						1	2	3	4
648	1.5.2.6.1.2	PDR	11/23/06	11/23/06	0 d						1	2	3	4
649	1.5.2.6.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d						1	2	3	4
650	1.5.2.6.1.4	CDR	1/17/08	1/17/08	0 d						1	2	3	4
651	1.5.2.6.2	Flight Fab, Assembly & Test	2/4/08	1/17/08	200 d						1	2	3	4
652	1.5.2.7	Telescope	9/30/05	3/27/09	911 d						1	2	3	4
653	1.5.2.7.1	Design	9/30/05	1/17/08	600 d						1	2	3	4
654	1.5.2.7.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d						1	2	3	4
655	1.5.2.7.1.2	PDR	11/23/06	11/23/06	0 d						1	2	3	4
656	1.5.2.7.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d						1	2	3	4
657	1.5.2.7.1.4	CDR	1/17/08	1/17/08	0 d						1	2	3	4
658	1.5.2.7.2	Flight Fab & Assembly	2/4/08	8/29/08	150 d						1	2	3	4
659	1.5.2.7.2.1	Primary Optics	2/4/08	8/29/08	150 d						1	2	3	4
660	1.5.2.7.2.2	Secondary Optics	2/4/08	8/29/08	150 d						1	2	3	4
661	1.5.2.7.2.3	Telescope Structure	2/4/08	8/29/08	150 d						1	2	3	4
662	1.5.2.7.3	Integration & Test	1/18/08	3/27/09	311 d						1	2	3	4
663	1.5.2.7.3.1	Telescope EM I&T	1/18/08	4/10/08	60 d						1	2	3	4
664	1.5.2.7.3.2	Telescope FM1 I&T	9/11/08	11/14/08	55 d						1	2	3	4
665	1.5.2.7.3.3	Telescope FM2 I&T	11/17/08	1/23/09	50 d						1	2	3	4
666	1.5.2.7.3.4	Telescope FM3 I&T	1/26/09	3/27/09	45 d						1	2	3	4

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
667	1.5.2.8	Optical Assembly Actuator	9/30/05	5/1/09	936 d	4	1	2	3	4	1	2	3	4
668	1.5.2.8.1	Design	9/30/05	1/17/08	600 d									
669	1.5.2.8.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
670	1.5.2.8.1.2	PDR	11/23/06	11/23/06	0 d									
671	1.5.2.8.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
672	1.5.2.8.1.4	CDR	1/17/08	1/17/08	0 d									
673	1.5.2.8.2	Flight Fab & Assembly	2/4/08	10/24/08	190 d									
674	1.5.2.8.2.1	Actuator Mechanism	2/4/08	10/24/08	190 d									
675	1.5.2.8.2.2	Actuator Electronics	2/4/08	10/24/08	190 d									
676	1.5.2.8.3	Integration & Test	1/18/08	5/1/09	336 d									
677	1.5.2.8.3.1	OA Actuator EM I&T	1/18/08	4/10/08	60 d									
678	1.5.2.8.3.2	OA Actuator FM1 I&T	10/27/08	1/2/09	50 d									
679	1.5.2.8.3.3	OA Actuator FM2 I&T	1/5/09	3/6/09	45 d									
680	1.5.2.8.3.4	OA Actuator FM3 I&T	3/9/09	5/1/09	40 d									
681	1.5.3	Gravitational Reference Sensor	9/30/05	11/10/09	1073 d									
682	1.5.3.1	Flight Test Mass	9/30/05	9/12/08	771 d									
683	1.5.3.1.1	Design	9/30/05	2/1/08	611 d									
684	1.5.3.1.1.1	Preliminary Design & Breadboards	9/30/05	10/19/06	275 d									
685	1.5.3.1.1.2	PDR	11/3/06	11/3/06	0 d									
686	1.5.3.1.1.3	Detailed Design & Engineering Models	11/6/06	2/1/08	325 d									
687	1.5.3.1.1.4	CDR	2/1/08	2/1/08	0 d									
688	1.5.3.1.2	Flight Fab, Assembly & Test	2/4/08	9/12/08	160 d									
689	1.5.3.2	Caging	9/30/05	9/12/08	771 d									
690	1.5.3.2.1	Design	9/30/05	2/1/08	611 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
691	1.5.3.2.1.1	Preliminary Design & Breadboards	9/30/05	10/19/06	275 d	4	1							
692	1.5.3.2.1.2	PDR	11/3/06	11/3/06	0 d									
693	1.5.3.2.1.3	Detailed Design & Engineering Models	11/6/06	2/1/08	325 d									
694	1.5.3.2.1.4	CDR	2/1/08	2/1/08	0 d									
695	1.5.3.2.2	Flight Fab, Assembly & Test	2/4/08	9/12/08	160 d									
696	1.5.3.3	Housing & Electronics (Lightweight Test Mass) Design	9/30/05	11/14/08	816 d									
697	1.5.3.3.1		9/30/05	2/1/08	611 d									
698	1.5.3.3.1.1	Preliminary Design & Breadboards	9/30/05	10/19/06	275 d									
699	1.5.3.3.1.2	PDR	11/3/06	11/3/06	0 d									
700	1.5.3.3.1.3	Detailed Design & Engineering Models	11/6/06	2/1/08	325 d									
701	1.5.3.3.1.4	CDR	2/1/08	2/1/08	0 d									
702	1.5.3.3.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
703	1.5.3.3.2.1	Vacuum & Structure	2/4/08	8/1/08	130 d									
704	1.5.3.3.2.2	Electrode Housing	2/4/08	8/1/08	130 d									
705	1.5.3.3.2.3	Lightweight Test Mass & Special Caging	2/4/08	8/1/08	130 d									
706	1.5.3.3.2.4	Front End Electronics	2/4/08	8/1/08	130 d									
707	1.5.3.3.2.5	Control Electronics	2/4/08	8/1/08	130 d									
708	1.5.3.3.3	Integration & Test	2/4/08	11/14/08	205 d									
709	1.5.3.3.3.1	Housing & Electronics EM I&T	2/4/08	4/1/08	42 d									
710	1.5.3.3.3.2	Housing & Electronics FM1 I&T	8/4/08	9/12/08	30 d									
711	1.5.3.3.3.3	Housing & Electronics FM2 I&T	9/15/08	10/17/08	25 d									
712	1.5.3.3.3.4	Housing & Electronics FM3 I&T	10/20/08	11/14/08	20 d									
713	1.5.3.4	Charge Management Unit	9/30/05	11/14/08	816 d									
714	1.5.3.4.1	Design	9/30/05	2/1/08	611 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
715	1.5.3.4.1.1	Preliminary Design & Breadboards	9/30/05	10/19/06	275 d	4	1	2	3	4	1	2	3	4
716	1.5.3.4.1.2	PDR	11/3/06	11/3/06	0 d									
717	1.5.3.4.1.3	Detailed Design & Engineering Models	11/6/06	2/1/08	325 d									
718	1.5.3.4.1.4	CDR	2/1/08	2/1/08	0 d									
719	1.5.3.4.2	Flight Fab & Assembly	2/4/08	8/1/08	130 d									
720	1.5.3.4.2.1	Fibers	2/4/08	8/1/08	130 d									
721	1.5.3.4.2.2	UV Lamps	2/4/08	8/1/08	130 d									
722	1.5.3.4.2.3	UV Switch	2/4/08	8/1/08	130 d									
723	1.5.3.4.2.4	UV Control	2/4/08	8/1/08	130 d									
724	1.5.3.4.3	Integration & Test	2/4/08	11/14/08	205 d									
725	1.5.3.4.3.1	CMU EM I&T	2/4/08	4/1/08	42 d									
726	1.5.3.4.3.2	CMU FM1 I&T	8/4/08	9/12/08	30 d									
727	1.5.3.4.3.3	CMU FM2 I&T	9/15/08	10/17/08	25 d									
728	1.5.3.4.3.4	CMU FM3 I&T	10/20/08	11/14/08	20 d									
729	1.5.3.5	GRS I&T	4/2/08	11/10/09	420 d									
730	1.5.3.5.1	GRS EM I&T	4/2/08	10/7/08	135 d									
731	1.5.3.5.1.1	Initial Flight Sensor Integration	4/2/08	6/24/08	60 d									
732	1.5.3.5.1.2	Final Flight Sensor I&T	6/25/08	9/30/08	70 d									
733	1.5.3.5.1.3	Pack Ship & Delivery to NASA	10/1/08	10/7/08	5 d									
734	1.5.3.5.2	GRS FM1 I&T	10/1/08	2/17/09	100 d									
735	1.5.3.5.2.1	Initial Flight Sensor Integration	10/1/08	11/11/08	30 d									
736	1.5.3.5.2.2	Final Flight Sensor I&T	11/12/08	2/10/09	65 d									
737	1.5.3.5.2.3	Pack Ship & Delivery to NASA	2/11/09	2/17/09	5 d									
738	1.5.3.5.3	GRS FM2 I&T	2/11/09	6/30/09	100 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
739	1.5.3.5.3.1	Initial Flight Sensor Integration	2/11/09	3/24/09	30 d	4	1							
740	1.5.3.5.3.2	Final Flight Sensor I&T	3/25/09	6/23/09	65 d									
741	1.5.3.5.3.3	Pack, Ship & Delivery to NASA	6/24/09	6/30/09	5 d									
742	1.5.3.5.4	GRS FM3 I&T	6/24/09	11/10/09	100 d									
743	1.5.3.5.4.1	Initial Flight Sensor Integration	6/24/09	8/4/09	30 d									
744	1.5.3.5.4.2	Final Flight Sensor I&T	8/5/09	11/3/09	65 d									
745	1.5.3.5.4.3	Pack, Ship & Delivery to NASA	11/4/09	11/10/09	5 d									
746	1.5.4	Y-Tube Assembly	9/30/05	5/15/09	946 d									
747	1.5.4.1	Aft Fiber	9/30/05	9/12/08	771 d									
748	1.5.4.1.1	Design	9/30/05	1/17/08	600 d									
749	1.5.4.1.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
750	1.5.4.1.1.2	PDR	11/23/06	11/23/06	0 d									
751	1.5.4.1.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
752	1.5.4.1.1.4	CDR	1/17/08	1/17/08	0 d									
753	1.5.4.1.2	Flight Fab, Assembly & Test	2/4/08	9/12/08	160 d									
754	1.5.4.2	Ultra Stable Structure	9/30/05	5/15/09	946 d									
755	1.5.4.2.1	Design	9/30/05	1/17/08	600 d									
756	1.5.4.2.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
757	1.5.4.2.1.2	PDR	11/23/06	11/23/06	0 d									
758	1.5.4.2.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
759	1.5.4.2.1.4	CDR	1/17/08	1/17/08	0 d									
760	1.5.4.2.2	Flight Fab & Assembly	2/4/08	1/17/08	200 d									
761	1.5.4.2.2.1	Radiator	2/4/08	1/17/08	200 d									
762	1.5.4.2.2.2	Y-tube Structure	2/4/08	1/17/08	200 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
763	1.5.4.2.2.3	Aft-bulkhead	2/4/08	11/7/08	200 d	4	1							
764	1.5.4.2.3	Integration & Test	1/18/08	5/15/09	346 d									
765	1.5.4.2.3.1	USS EM I&T	1/18/08	4/10/08	60 d									
766	1.5.4.2.3.2	USS FM1 I&T	11/10/08	1/16/09	50 d									
767	1.5.4.2.3.3	USS FM2 I&T	1/19/09	3/20/09	45 d									
768	1.5.4.2.3.4	USS FM3 I&T	3/23/09	5/15/09	40 d									
769	1.5.5	Payload Processor / Controller	9/30/05	3/13/09	901 d									
770	1.5.5.1	Design	9/30/05	1/17/08	600 d									
771	1.5.5.1.1	Preliminary Design & Breadboards	9/30/05	11/23/06	300 d									
772	1.5.5.1.2	PDR	11/23/06	11/23/06	0 d									
773	1.5.5.1.3	Detailed Design & Engineering Models	11/24/06	1/17/08	300 d									
774	1.5.5.1.4	CDR	1/17/08	1/17/08	0 d									
775	1.5.5.2	Flight Fab & Assembly	2/4/08	8/15/08	140 d									
776	1.5.5.3	Integration & Test	1/18/08	3/13/09	301 d									
777	1.5.5.3.1	Processor EM I&T	1/18/08	4/10/08	60 d									
778	1.5.5.3.2	Processor FM1 I&T	8/18/08	10/31/08	55 d									
779	1.5.5.3.3	Processor FM2 I&T	11/3/08	1/9/09	50 d									
780	1.5.5.3.4	Processor FM3 I&T	1/12/09	3/13/09	45 d									
781	1.5.6	Payload Integration & Test	4/9/07	3/19/10	770 d									
782	1.5.6.1	Optical Bench Assy Initial Integration (Dummy GRS)	4/9/07	1/23/09	470 d									
783	1.5.6.1.1	Set-Up Integration Facility & GSE	4/9/07	8/10/07	90 d									
784	1.5.6.1.2	Optical Bench Assy EM I&T	2/4/08	5/23/08	80 d									
785	1.5.6.1.2.1	Optical Bench Assy EM I&T	2/4/08	5/16/08	75 d									
786	1.5.6.1.2.2	Pack, Ship & Delivery to ESA	5/19/08	5/23/08	5 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
787	1.5.6.1.3	Optical Bench Assy FM1 I&T	8/4/08	10/10/08	50 d	4	1	2	3	4	1	2	3	4
788	1.5.6.1.3.1	Optical Bench Assy FM1 I&T	8/4/08	10/3/08	45 d									
789	1.5.6.1.3.2	Pack, Ship & Deliver to ESA	10/6/08	10/10/08	5 d									
790	1.5.6.1.4	Optical Bench Assy FM2 I&T	10/6/08	12/5/08	45 d									
791	1.5.6.1.4.1	Optical Bench Assy FM2 I&T	10/6/08	11/28/08	40 d									
792	1.5.6.1.4.2	Pack, Ship & Deliver to ESA	12/1/08	12/5/08	5 d									
793	1.5.6.1.5	Optical Bench Assy FM3 I&T	12/1/08	1/23/09	40 d									
794	1.5.6.1.5.1	Optical Bench Assy FM3 I&T	12/1/08	1/16/09	35 d									
795	1.5.6.1.5.2	Pack, Ship & Deliver to ESA	1/19/09	1/23/09	5 d									
796	1.5.6.2	Electro-Optical Integration (Dummy GRS)	5/26/08	5/22/09	260 d									
797	1.5.6.2.1	Electro-Optical EM I&T	5/26/08	8/22/08	65 d									
798	1.5.6.2.1.1	Electro-Optical EM I&T	5/26/08	8/15/08	60 d									
799	1.5.6.2.1.2	Pack, Ship & Delivery to NASA	8/18/08	8/22/08	5 d									
800	1.5.6.2.2	Electro-Optical FM1 I&T	11/3/08	1/16/09	55 d									
801	1.5.6.2.2.1	Electro-Optical FM1 I&T	11/3/08	1/9/09	50 d									
802	1.5.6.2.2.2	Pack, Ship & Delivery to NASA	1/12/09	1/16/09	5 d									
803	1.5.6.2.3	Electro-Optical FM2 I&T	1/12/09	3/20/09	50 d									
804	1.5.6.2.3.1	Electro-Optical FM2 I&T	1/12/09	3/13/09	45 d									
805	1.5.6.2.3.2	Pack, Ship & Delivery to NASA	3/16/09	3/20/09	5 d									
806	1.5.6.2.4	Electro-Optical FM3 I&T	3/23/09	5/22/09	45 d									
807	1.5.6.2.4.1	Electro-Optical FM3 I&T	3/23/09	5/15/09	40 d									
808	1.5.6.2.4.2	Pack, Ship & Delivery to NASA	5/18/09	5/22/09	5 d									
809	1.5.6.3	Optical Assembly Integration (Dummy GRS)	8/25/08	7/3/09	225 d									
810	1.5.6.3.1	Optical Assy EM I&T	8/25/08	11/14/08	60 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
						4	1	2	3	4	1	2	3	4
811	1.5.6.3.2	Optical Assy FM1 I&T	1/26/09	3/20/09	40 d									
812	1.5.6.3.3	Optical Assy FM2 I&T	3/23/09	5/8/09	35 d									
813	1.5.6.3.4	Optical Assy FM3 I&T	5/25/09	7/3/09	30 d									
814	1.5.6.4	Optical Assembly Final Integration (Flight GRS)	11/17/08	12/22/09	287 d									
815	1.5.6.4.1	Optical Assy EM Final I&T	11/17/08	2/6/09	60 d									
816	1.5.6.4.2	Optical Assy FM1 Final I&T	3/23/09	5/15/09	40 d									
817	1.5.6.4.3	Optical Assy FM2 Final I&T	7/1/09	8/18/09	35 d									
818	1.5.6.4.4	Optical Assy FM3 Final I&T	11/11/09	12/22/09	30 d									
819	1.5.6.5	Y-Tube Integration (2 work stations)	2/9/09	3/19/10	290 d									
820	1.5.6.5.1	Y-Tube EM I&T	2/9/09	6/24/09	98 d									
821	1.5.6.5.1.1	I&T	2/9/09	4/24/09	55 d									
822	1.5.6.5.1.2	Schedule Reserve	4/27/09	6/5/09	30 d									
823	1.5.6.5.1.3	Pack, Ship & Deliver to NASA	6/8/09	6/24/09	13 d									
824	1.5.6.5.1.3.1	Pre-Ship Review Preparations	6/8/09	6/12/09	5 d									
825	1.5.6.5.1.3.2	Pre-Ship Review	6/12/09	6/12/09	0 d									
826	1.5.6.5.1.3.3	Ship to Observatory Contractor	6/15/09	6/17/09	3 d									
827	1.5.6.5.1.3.4	Post-Delivery Inspection & Checkout	6/18/09	6/24/09	5 d									
828	1.5.6.5.1.3.5	Payload Turnover For Observatory	6/24/09	6/24/09	0 d									
829	1.5.6.5.2	Y-Tube FM1 I&T	6/8/09	9/16/09	73 d									
830	1.5.6.5.2.1	I&T	6/8/09	7/31/09	40 d									
831	1.5.6.5.2.2	FM1 PER	6/16/09	6/16/09	0 d									
832	1.5.6.5.2.3	Schedule Reserve	8/3/09	8/28/09	20 d									
833	1.5.6.5.2.4	Pack, Ship & Deliver to NASA	8/31/09	9/16/09	13 d									
834	1.5.6.5.2.4.1	Pre-Ship Review Preparations	8/31/09	9/4/09	5 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
835	1.5.6.5.2.4.2	Pre-Ship Review	9/4/09	9/4/09	0 d	4	1	2	3	4	1	2	3	4
836	1.5.6.5.2.4.3	Ship to Observatory Contractor	9/7/09	9/9/09	3 d									
837	1.5.6.5.2.4.4	Post-Delivery Inspection & Checkout	9/10/09	9/16/09	5 d									
838	1.5.6.5.2.4.5	Payload Turnover For Observatory	9/16/09	9/16/09	0 d									
839	1.5.6.5.3	Y-Tube FM2 I&T	8/31/09	12/2/09	68 d									
840	1.5.6.5.3.1	I&T	8/31/09	10/16/09	35 d									
841	1.5.6.5.3.2	PER	9/8/09	9/8/09	0 d									
842	1.5.6.5.3.3	Schedule Reserve	10/19/09	11/13/09	20 d									
843	1.5.6.5.3.4	Pack, Ship & Deliver to NASA	11/16/09	12/2/09	13 d									
844	1.5.6.5.3.4.1	Pre-Ship Review Preparations	11/16/09	11/20/09	5 d									
845	1.5.6.5.3.4.2	Pre-Ship Review	11/20/09	11/20/09	0 d									
846	1.5.6.5.3.4.3	Ship to Observatory Contractor	11/23/09	11/25/09	3 d									
847	1.5.6.5.3.4.4	Post-Delivery Inspection & Checkout	11/26/09	12/2/09	5 d									
848	1.5.6.5.3.4.5	Payload Turnover For Observatory	12/2/09	12/2/09	0 d									
849	1.5.6.5.4	Y-Tube FM3 I&T	12/23/09	3/19/10	63 d									
850	1.5.6.5.4.1	I&T	12/23/09	2/2/10	30 d									
851	1.5.6.5.4.2	PER	12/31/09	12/31/09	0 d									
852	1.5.6.5.4.3	Schedule Reserve	2/3/10	3/2/10	20 d									
853	1.5.6.5.4.4	Pack, Ship & Deliver to NASA	3/3/10	3/19/10	13 d									
854	1.5.6.5.4.4.1	Pre-Ship Review Preparations	3/3/10	3/9/10	5 d									
855	1.5.6.5.4.4.2	Pre-Ship Review	3/9/10	3/9/10	0 d									
856	1.5.6.5.4.4.3	Ship to Observatory Contractor	3/10/10	3/12/10	3 d									
857	1.5.6.5.4.4.4	Post-Delivery Inspection & Checkout	3/15/10	3/19/10	5 d									
858	1.5.6.5.4.4.5	Payload Turnover For Observatory	3/19/10	3/19/10	0 d									

FLIGHT SYSTEM WBS 1.6

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
859	1.6	Flight System	10/1/03	8/15/11	2054 d	4	1	2	3	4	1	2	3	4
860	1.6.1	Spacecraft (ESA)	10/1/03	1/11/10	1639 d									
861	1.6.1.1	ESA Acquisition Cycle	10/1/03	3/22/06	646 d									
862	1.6.1.1.1	Definition Phase ITT	10/1/03	10/1/03	0 d									
863	1.6.1.1.2	Definition Phase Acquisition Cycle	10/1/03	4/1/04	132 d									
864	1.6.1.1.3	Definition Phase Kick-off	4/1/04	4/1/04	0 d									
865	1.6.1.1.4	Implementation Phase ITT	9/13/05	9/13/05	0 d									
866	1.6.1.1.5	Implementation Phase Acquisition Cycle	9/13/05	3/22/06	137 d									
867	1.6.1.1.6	Implementation Phase Kick-off	3/22/06	3/22/06	0 d									
868	1.6.1.2	Spacecraft System Engineering / Management	4/2/04	8/5/09	1394 d									
869	1.6.1.2.1	Preliminary Mission Architecture	4/2/04	8/5/04	90 d									
870	1.6.1.2.2	Spacecraft & Technology Conc.	8/6/04	12/6/04	87 d									
871	1.6.1.2.3	Mission Definition & Design	12/7/04	4/7/05	88 d									
872	1.6.1.2.4	Spacecraft PDR	4/12/07	4/12/07	0 d									
873	1.6.1.2.5	Spacecraft CDR	3/13/08	3/13/08	0 d									
874	1.6.1.2.6	S/C Bus Flight 1 PER	2/25/09	2/25/09	0 d									
875	1.6.1.2.7	S/C Bus Flight 2 PER	5/20/09	5/20/09	0 d									
876	1.6.1.2.8	S/C Bus Flight 3 PER	8/5/09	8/5/09	0 d									
877	1.6.1.3	Spacecraft Bus	3/23/06	9/30/09	920 d									
878	1.6.1.3.1	Structures / Mechanisms Subsystem	3/23/06	12/17/08	715 d									
879	1.6.1.3.1.1	Structure & Mechanism	3/23/06	12/17/08	715 d									
880	1.6.1.3.1.1.1	Design	3/23/06	2/6/08	490 d									
881	1.6.1.3.1.1.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
882	1.6.1.3.1.1.1.2	PDR	3/7/07	3/7/07	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
883	1.6.1.3.1.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d	4	1							
884	1.6.1.3.1.1.4	CDR	2/6/08	2/6/08	0 d									
885	1.6.1.3.1.1.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
886	1.6.1.3.1.2	Secondary Structure	3/23/06	12/17/08	715 d									
887	1.6.1.3.1.2.1	Design	3/23/06	2/6/08	490 d									
888	1.6.1.3.1.2.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
889	1.6.1.3.1.2.1.2	PDR	3/7/07	3/7/07	0 d									
890	1.6.1.3.1.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
891	1.6.1.3.1.2.1.4	CDR	2/6/08	2/6/08	0 d									
892	1.6.1.3.1.2.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
893	1.6.1.3.2	Power Subsystem	3/23/06	1/14/09	735 d									
894	1.6.1.3.2.1	Solar Array	3/23/06	1/14/09	735 d									
895	1.6.1.3.2.1.1	Design	3/23/06	2/6/08	490 d									
896	1.6.1.3.2.1.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
897	1.6.1.3.2.1.1.2	PDR	3/7/07	3/7/07	0 d									
898	1.6.1.3.2.1.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
899	1.6.1.3.2.1.1.4	CDR	2/6/08	2/6/08	0 d									
900	1.6.1.3.2.1.2	Flight Fab, Assembly & Test	3/13/08	1/14/09	220 d									
901	1.6.1.3.2.2	Battery	3/23/06	12/31/08	725 d									
902	1.6.1.3.2.2.1	Design	3/23/06	2/6/08	490 d									
903	1.6.1.3.2.2.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
904	1.6.1.3.2.2.1.2	PDR	3/7/07	3/7/07	0 d									
905	1.6.1.3.2.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
906	1.6.1.3.2.2.1.4	CDR	2/6/08	2/6/08	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
907	1.6.1.3.2.2.2	Flight Fab. Assembly & Test	3/13/08	12/31/08	210 d	4	1							
908	1.6.1.3.2.3	Power Control Distribution Unit Design	3/23/06	12/3/08	705 d									
909	1.6.1.3.2.3.1		3/23/06	2/6/08	490 d									
910	1.6.1.3.2.3.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
911	1.6.1.3.2.3.1.2		3/7/07	3/7/07	0 d									
912	1.6.1.3.2.3.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
913	1.6.1.3.2.3.1.4	CDR	2/6/08	2/6/08	0 d									
914	1.6.1.3.2.3.2	Flight Fab. Assembly & Test	3/13/08	12/3/08	190 d									
915	1.6.1.3.3	Command & Data Handling Subsystem Design	3/23/06	2/11/09	755 d									
916	1.6.1.3.3.1		3/23/06	2/6/08	490 d									
917	1.6.1.3.3.1.1	Preliminary Design & Breadboards	3/23/06	3/7/07	250 d									
918	1.6.1.3.3.1.2	PDR	3/7/07	3/7/07	0 d									
919	1.6.1.3.3.1.3	Detailed Design & Engineering Models	3/8/07	2/6/08	240 d									
920	1.6.1.3.3.1.4	CDR	2/6/08	2/6/08	0 d									
921	1.6.1.3.3.2	Flight Fab. Assembly & Test	3/13/08	2/11/09	240 d									
922	1.6.1.3.4	Telecom Subsystem	3/23/06	1/14/09	735 d									
923	1.6.1.3.4.1	Transponders	3/23/06	1/14/09	735 d									
924	1.6.1.3.4.1.1	Design	3/23/06	2/6/08	490 d									
925	1.6.1.3.4.1.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
926	1.6.1.3.4.1.1.2		3/7/07	3/7/07	0 d									
927	1.6.1.3.4.1.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
928	1.6.1.3.4.1.1.4	CDR	2/6/08	2/6/08	0 d									
929	1.6.1.3.4.1.2	Flight Fab. Assembly & Test	3/13/08	1/14/09	220 d									
930	1.6.1.3.4.2	RFDU	3/23/06	12/3/08	705 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
						4	1	2	3	4	1	2	3	4
931	1.6.1.3.4.2.1	Design	3/23/06	2/6/08	490 d									
932	1.6.1.3.4.2.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
933	1.6.1.3.4.2.1.2		3/7/07	3/7/07	0 d									
934	1.6.1.3.4.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
935	1.6.1.3.4.2.1.4	CDR	2/6/08	2/6/08	0 d									
936	1.6.1.3.4.2.2	Flight Fab, Assembly & Test	3/13/08	12/3/08	190 d									
937	1.6.1.3.4.3	SSPA	3/23/06	12/3/08	705 d									
938	1.6.1.3.4.3.1	Design	3/23/06	2/6/08	490 d									
939	1.6.1.3.4.3.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
940	1.6.1.3.4.3.1.2		3/7/07	3/7/07	0 d									
941	1.6.1.3.4.3.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
942	1.6.1.3.4.3.1.4	CDR	2/6/08	2/6/08	0 d									
943	1.6.1.3.4.3.2	Flight Fab, Assembly & Test	3/13/08	12/3/08	190 d									
944	1.6.1.3.4.4	TWT	3/23/06	12/3/08	705 d									
945	1.6.1.3.4.4.1	Design	3/23/06	2/6/08	490 d									
946	1.6.1.3.4.4.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
947	1.6.1.3.4.4.1.2		3/7/07	3/7/07	0 d									
948	1.6.1.3.4.4.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
949	1.6.1.3.4.4.1.4	CDR	2/6/08	2/6/08	0 d									
950	1.6.1.3.4.4.2	Flight Fab, Assembly & Test	3/13/08	12/3/08	190 d									
951	1.6.1.3.4.5	High Gain Antenna	3/23/06	11/19/08	695 d									
952	1.6.1.3.4.5.1	Design	3/23/06	2/6/08	490 d									
953	1.6.1.3.4.5.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
954	1.6.1.3.4.5.1.2		3/7/07	3/7/07	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
						4	1	2	3	4	1	2	3	4
955	1.6.1.3.4.5.1.3	Detailed Design & Engineering CDR	3/8/07	2/6/08	240 d									
956	1.6.1.3.4.5.1.4		2/6/08	2/6/08	0 d									
957	1.6.1.3.4.5.2	Flight Fab, Assembly & Test	3/13/08	11/19/08	180 d									
958	1.6.1.3.4.6	Low Gain Antenna	3/23/06	11/19/08	695 d									
959	1.6.1.3.4.6.1	Design	3/23/06	2/6/08	490 d									
960	1.6.1.3.4.6.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
961	1.6.1.3.4.6.1.2		3/7/07	3/7/07	0 d									
962	1.6.1.3.4.6.1.3	Detailed Design & Engineering CDR	3/8/07	2/6/08	240 d									
963	1.6.1.3.4.6.1.4		2/6/08	2/6/08	0 d									
964	1.6.1.3.4.6.2	Flight Fab, Assembly & Test	3/13/08	11/19/08	180 d									
965	1.6.1.3.4.7	Telecom Cabling Antenna	3/23/06	11/19/08	695 d									
966	1.6.1.3.4.7.1	Design	3/23/06	2/6/08	490 d									
967	1.6.1.3.4.7.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
968	1.6.1.3.4.7.1.2		3/7/07	3/7/07	0 d									
969	1.6.1.3.4.7.1.3	Detailed Design & Engineering CDR	3/8/07	2/6/08	240 d									
970	1.6.1.3.4.7.1.4		2/6/08	2/6/08	0 d									
971	1.6.1.3.4.7.2	Flight Fab, Assembly & Test	3/13/08	11/19/08	180 d									
972	1.6.1.3.5	Attitude Control Subsystem	3/23/06	2/11/09	755 d									
973	1.6.1.3.5.1	Star Camera Assy Optical Head & Electronics	3/23/06	1/14/09	735 d									
974	1.6.1.3.5.1.1	Design	3/23/06	2/6/08	490 d									
975	1.6.1.3.5.1.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
976	1.6.1.3.5.1.1.2		3/7/07	3/7/07	0 d									
977	1.6.1.3.5.1.1.3	Detailed Design & Engineering CDR	3/8/07	2/6/08	240 d									
978	1.6.1.3.5.1.1.4		2/6/08	2/6/08	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
979	1.6.1.3.5.1.2	Flight Fab, Assembly & Test	3/13/08	1/14/09	220 d	4	1	2	3	4	1	2	3	4
980	1.6.1.3.5.2	Sun Sensor	3/23/06	1/14/09	735 d									
981	1.6.1.3.5.2.1	Design	3/23/06	2/6/08	490 d									
982	1.6.1.3.5.2.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
983	1.6.1.3.5.2.1.2	PDR	3/7/07	3/7/07	0 d									
984	1.6.1.3.5.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
985	1.6.1.3.5.2.1.4	CDR	2/6/08	2/6/08	0 d									
986	1.6.1.3.5.2.2	Flight Fab, Assembly & Test	3/13/08	1/14/09	220 d									
987	1.6.1.3.5.3	Aft Anomaly Detector	3/23/06	12/17/08	715 d									
988	1.6.1.3.5.3.1	Design	3/23/06	2/6/08	490 d									
989	1.6.1.3.5.3.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
990	1.6.1.3.5.3.1.2	PDR	3/7/07	3/7/07	0 d									
991	1.6.1.3.5.3.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
992	1.6.1.3.5.3.1.4	CDR	2/6/08	2/6/08	0 d									
993	1.6.1.3.5.3.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
994	1.6.1.3.5.4	Magnetometer	3/23/06	2/11/09	755 d									
995	1.6.1.3.5.4.1	Design	3/23/06	2/6/08	490 d									
996	1.6.1.3.5.4.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
997	1.6.1.3.5.4.1.2	PDR	3/7/07	3/7/07	0 d									
998	1.6.1.3.5.4.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
999	1.6.1.3.5.4.1.4	CDR	2/6/08	2/6/08	0 d									
1000	1.6.1.3.5.4.2	Flight Fab, Assembly & Test	3/13/08	2/11/09	240 d									
1001	1.6.1.3.5.5	FEPP Assembly	3/23/06	12/3/08	705 d									
1002	1.6.1.3.5.5.1	Design	3/23/06	2/6/08	490 d									

ID	WBS	Description	Start	Finish	Duration	2003				2004				2005				2006				2007				2008				2009				2010				2011																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
						4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
1003	1.6.1.3.5.5.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							</

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1027	1.6.1.3.7.1.4	CDR	2/6/08	2/6/08	0 d	4	1							
1028	1.6.1.3.7.2	Flight Fab, Assembly & Test	3/13/08	11/19/08	180 d									
1029	1.6.1.3.8	S/C Bus I&T	3/13/08	9/30/09	405 d									
1030	1.6.1.3.8.1	S/C Bus EM I&T	3/13/08	7/16/08	90 d									
1031	1.6.1.3.8.2	S/C Bus FM1 I&T	2/12/09	5/6/09	60 d									
1032	1.6.1.3.8.3	S/C Bus FM2 I&T	5/7/09	7/22/09	55 d									
1033	1.6.1.3.8.4	S/C Bus FM3 I&T	7/23/09	9/30/09	50 d									
1034	1.6.1.4	Propulsion Module	3/23/06	9/2/09	900 d									
1035	1.6.1.4.1	Structure	3/23/06	12/17/08	715 d									
1036	1.6.1.4.1.1	Primary Structure	3/23/06	12/17/08	715 d									
1037	1.6.1.4.1.1.1	Design	3/23/06	2/6/08	490 d									
1038	1.6.1.4.1.1.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
1039	1.6.1.4.1.1.1.2		3/7/07	3/7/07	0 d									
1040	1.6.1.4.1.1.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1041	1.6.1.4.1.1.1.4	CDR	2/6/08	2/6/08	0 d									
1042	1.6.1.4.1.1.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
1043	1.6.1.4.1.2	Secondary Structure	3/23/06	12/17/08	715 d									
1044	1.6.1.4.1.2.1	Design	3/23/06	2/6/08	490 d									
1045	1.6.1.4.1.2.1.1	Preliminary Design & PDR	3/23/06	3/7/07	250 d									
1046	1.6.1.4.1.2.1.2		3/7/07	3/7/07	0 d									
1047	1.6.1.4.1.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1048	1.6.1.4.1.2.1.4	CDR	2/6/08	2/6/08	0 d									
1049	1.6.1.4.1.2.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
1050	1.6.1.4.2	Chemical Propulsion	3/23/06	1/14/09	735 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
						4	1	2	3	4	1	2	3	4
1051	1.6.1.4.2.1	Fuel Tanks	3/23/06	1/14/09	735 d									
1052	1.6.1.4.2.1.1	Design	3/23/06	2/6/08	490 d									
1053	1.6.1.4.2.1.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
1054	1.6.1.4.2.1.1.2	PDR	3/7/07	3/7/07	0 d									
1055	1.6.1.4.2.1.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1056	1.6.1.4.2.1.1.4	CDR	2/6/08	2/6/08	0 d									
1057	1.6.1.4.2.1.2	Flight Fab, Assembly & Test	3/13/08	1/14/09	220 d									
1058	1.6.1.4.2.2	Pressurant Tanks	3/23/06	1/14/09	735 d									
1059	1.6.1.4.2.2.1	Design	3/23/06	2/6/08	490 d									
1060	1.6.1.4.2.2.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
1061	1.6.1.4.2.2.1.2	PDR	3/7/07	3/7/07	0 d									
1062	1.6.1.4.2.2.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1063	1.6.1.4.2.2.1.4	CDR	2/6/08	2/6/08	0 d									
1064	1.6.1.4.2.2.2	Flight Fab, Assembly & Test	3/13/08	1/14/09	220 d									
1065	1.6.1.4.2.3	Filters, Valves & Regulators	3/23/06	12/17/08	715 d									
1066	1.6.1.4.2.3.1	Design	3/23/06	2/6/08	490 d									
1067	1.6.1.4.2.3.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
1068	1.6.1.4.2.3.1.2	PDR	3/7/07	3/7/07	0 d									
1069	1.6.1.4.2.3.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1070	1.6.1.4.2.3.1.4	CDR	2/6/08	2/6/08	0 d									
1071	1.6.1.4.2.3.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
1072	1.6.1.4.2.4	RCS Thruster Assembly	3/23/06	12/17/08	715 d									
1073	1.6.1.4.2.4.1	Design	3/23/06	2/6/08	490 d									
1074	1.6.1.4.2.4.1.1	Preliminary Design &	3/23/06	3/7/07	250 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1075	1.6.1.4.2.4.1.2	PDR	3/7/07	3/7/07	0 d	4	1	2	3	4	1	2	3	4
1076	1.6.1.4.2.4.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1077	1.6.1.4.2.4.1.4	CDR	2/6/08	2/6/08	0 d									
1078	1.6.1.4.2.4.2	Flight Fab, Assembly & Test	3/13/08	12/17/08	200 d									
1079	1.6.1.4.2.5	Heaters	3/23/06	10/22/08	675 d									
1080	1.6.1.4.2.5.1	Design	3/23/06	2/6/08	490 d									
1081	1.6.1.4.2.5.1.1	Preliminary Design	3/23/06	3/7/07	250 d									
1082	1.6.1.4.2.5.1.2	PDR	3/7/07	3/7/07	0 d									
1083	1.6.1.4.2.5.1.3	Detailed Design & Engineering	3/8/07	2/6/08	240 d									
1084	1.6.1.4.2.5.1.4	CDR	2/6/08	2/6/08	0 d									
1085	1.6.1.4.2.5.2	Flight Fab, Assembly & Test	3/13/08	10/22/08	160 d									
1086	1.6.1.4.3	Integration & Test	3/13/08	9/2/09	385 d									
1087	1.6.1.4.3.1	Propulsion Module EM I&T	3/13/08	7/2/08	80 d									
1088	1.6.1.4.3.2	Propulsion Module FM1 I&T	1/15/09	4/8/09	60 d									
1089	1.6.1.4.3.3	Propulsion Module FM2 I&T	4/9/09	6/24/09	55 d									
1090	1.6.1.4.3.4	Propulsion Module FM3 I&T	6/25/09	9/2/09	50 d									
1091	1.6.1.5	Spacecraft I&T (Bus & Propulsion Module)	7/17/08	1/11/10	388 d									
1092	1.6.1.5.1	Spacecraft EM I&T	7/17/08	3/30/09	183 d									
1093	1.6.1.5.1.1	S/C Bus-To-Propulsion Module Compatibility	7/17/08	11/19/08	90 d									
1094	1.6.1.5.1.2	Schedule Reserve	11/20/08	3/11/09	80 d									
1095	1.6.1.5.1.3	Pack, Ship & Deliver Spacecraft to	3/12/09	3/30/09	13 d									
1096	1.6.1.5.1.3.1	Pre-Ship Review Preparations	3/12/09	3/18/09	5 d									
1097	1.6.1.5.1.3.2	Pre-Ship Review	3/18/09	3/18/09	0 d									
1098	1.6.1.5.1.3.3	Ship to Observatory Contractor	3/19/09	3/23/09	3 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1099	1.6.1.5.1.3.4	Post-Delivery Inspection & Checkout	3/24/09	3/30/09	5 d	4	1	2	3	4	1	2	3	4
1100	1.6.1.5.1.3.5	Spacecraft Turnover for Observatory I&T	3/30/09	3/30/09	0 d							△ 3/30		
1101	1.6.1.5.2	Spacecraft Flight 1 I&T	5/7/09	8/17/09	73 d							↔		
1102	1.6.1.5.2.1	S/C Bus-To-Propulsion Module Compatibility	5/7/09	7/1/09	40 d							□		
1103	1.6.1.5.2.2	Schedule Reserve	7/2/09	7/29/09	20 d							□		
1104	1.6.1.5.2.3	Pack, Ship & Deliver Spacecraft to	7/30/09	8/17/09	13 d							↔		
1105	1.6.1.5.2.3.1	Pre-Ship Review Preparations	7/30/09	8/5/09	5 d							□		
1106	1.6.1.5.2.3.2	Pre-Ship Review	8/5/09	8/5/09	0 d							△ 8/5		
1107	1.6.1.5.2.3.3	Ship to Observatory Contractor	8/6/09	8/10/09	3 d							□		
1108	1.6.1.5.2.3.4	Post-Delivery Inspection & Checkout	8/11/09	8/17/09	5 d							□		
1109	1.6.1.5.2.3.5	Spacecraft Turnover for Observatory I&T	8/17/09	8/17/09	0 d							△ 8/17		
1110	1.6.1.5.3	Spacecraft Flight 2 I&T	7/30/09	11/2/09	68 d							↔		
1111	1.6.1.5.3.1	S/C Bus-To-Propulsion Module Compatibility	7/30/09	9/16/09	35 d							□		
1112	1.6.1.5.3.2	Schedule Reserve	9/17/09	10/14/09	20 d							□		
1113	1.6.1.5.3.3	Pack, Ship & Deliver Spacecraft to	10/15/09	11/2/09	13 d							↔		
1114	1.6.1.5.3.3.1	Pre-Ship Review Preparations	10/15/09	10/21/09	5 d							□		
1115	1.6.1.5.3.3.2	Pre-Ship Review	10/21/09	10/21/09	0 d							△ 10/21		
1116	1.6.1.5.3.3.3	Ship to Observatory Contractor	10/22/09	10/26/09	3 d							□		
1117	1.6.1.5.3.3.4	Post-Delivery Inspection & Checkout	10/27/09	11/2/09	5 d							□		
1118	1.6.1.5.3.3.5	Spacecraft Turnover for Observatory I&T	11/2/09	11/2/09	0 d							△ 11/2		
1119	1.6.1.5.4	Spacecraft Flight 3 I&T	10/15/09	1/11/10	63 d							↔		
1120	1.6.1.5.4.1	S/C Bus-To-Propulsion Module Compatibility	10/15/09	11/25/09	30 d							□		
1121	1.6.1.5.4.2	Schedule Reserve	11/26/09	12/23/09	20 d							□		
1122	1.6.1.5.4.3	Pack, Ship & Deliver Spacecraft to	12/24/09	1/11/10	13 d							↔		

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1123	1.6.1.5.4.3.1	Pre-Ship Review Preparations	12/24/09	12/30/09	5 d	4	1	2	3	4	1	2	3	4
1124	1.6.1.5.4.3.2	Pre-Ship Review	12/30/09	12/30/09	0 d									
1125	1.6.1.5.4.3.3	Ship to Observatory Contractor	12/31/09	1/4/10	3 d									
1126	1.6.1.5.4.3.4	Post-Delivery Inspection & Checkout	1/5/10	1/11/10	5 d									
1127	1.6.1.5.4.3.5	Spacecraft Turnover for Observatory I&T	1/11/10	1/11/10	0 d									
1128	1.6.2	Observatory Integration & Test	6/2/08	9/3/10	590 d									
1129	1.6.2.1	Observatory EM (on Observatory Test Stand 1)	6/2/08	7/2/10	545 d									
1130	1.6.2.1.1	Set-Up & Checkout OTS #1	6/2/08	11/14/08	120 d									
1131	1.6.2.1.2	Install EM Spacecraft on OTS #1	3/31/09	4/13/09	10 d									
1132	1.6.2.1.3	Install Payload Structural Thermal Model (STM)	4/14/09	4/20/09	5 d									
1133	1.6.2.1.4	Remove EM Observatory from OTS #1 & Install into Vibration	4/21/09	4/27/09	5 d									
1134	1.6.2.1.5	Structural Dynamics Qualification Test	4/28/09	6/8/09	30 d									
1135	1.6.2.1.6	Re-Install Observatory EM on OTS #1	6/9/09	6/22/09	10 d									
1136	1.6.2.1.7	Install Payload EM	6/25/09	7/22/09	20 d									
1137	1.6.2.1.8	Observatory EM Performance Testing	7/23/09	10/14/09	60 d									
1138	1.6.2.1.9	Remove Observatory EM from OTS-1	10/15/09	10/21/09	5 d									
1139	1.6.2.1.10	Observatory EM Environmental Qual Test	10/22/09	1/13/10	60 d									
1140	1.6.2.1.11	Re-Install Observatory EM on OTS #1	2/1/10	2/12/10	10 d									
1141	1.6.2.1.12	Retrofit and Test Observatory EM for Flight Spare	2/15/10	4/23/10	50 d									
1142	1.6.2.1.13	Spare Observatory Reserve	4/26/10	7/2/10	50 d									
1143	1.6.2.2	Observatory Flight 1 (on Observatory Test Stand 2)	12/2/08	3/19/10	339 d									
1144	1.6.2.2.1	Set-Up & Checkout OTS #2	12/2/08	5/18/09	120 d									
1145	1.6.2.2.2	Install Spacecraft Flight 1	8/18/09	8/31/09	10 d									
1146	1.6.2.2.3	Install Payload FM1	9/17/09	9/30/09	10 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1147	1.6.2.2.4	Observatory Flight 1 Performance Test	10/1/09	11/18/09	35 d	4	1	2	3	4	1	2	3	4
1148	1.6.2.2.5	Pre-Environmental Review	10/28/09	10/28/09	0 d								△ 10/28	
1149	1.6.2.2.6	Remove Observatory Flight 1 from OTS-2	11/19/09	11/20/09	2 d									
1150	1.6.2.2.7	Observatory Flight 1 Environmental Test	11/23/09	1/22/10	45 d									
1151	1.6.2.2.8	Schedule Reserve	1/25/10	3/19/10	40 d									
1152	1.6.2.2.9	Turnover for Constellation Test	3/19/10	3/19/10	0 d								△ 3/19	
1153	1.6.2.3	Observatory Flight 2 (on Observatory Test Stand 1)	11/3/09	5/28/10	149 d									
1154	1.6.2.3.1	Install Spacecraft Flight 2 on OTS#1	11/3/09	11/16/09	10 d									
1155	1.6.2.3.2	Install Payload FM2	12/3/09	12/16/09	10 d									
1156	1.6.2.3.3	Observatory Flight 2 Performance Test	12/17/09	1/27/10	30 d									
1157	1.6.2.3.4	Pre-Environmental Review	1/6/10	1/6/10	0 d								△ 1/6	
1158	1.6.2.3.5	Remove Observatory Flight 2 from OTS-1	1/28/10	1/29/10	2 d									
1159	1.6.2.3.6	Observatory Flight 2 Environmental Test	2/1/10	4/2/10	45 d									
1160	1.6.2.3.7	Schedule Reserve	4/5/10	5/28/10	40 d									
1161	1.6.2.3.8	Turnover for Constellation Test	5/28/10	5/28/10	0 d								△ 5/28	
1162	1.6.2.4	Observatory Flight 3 (on Observatory Test Stand 2)	1/12/10	9/3/10	169 d									
1163	1.6.2.4.1	Install Spacecraft Flight 3 on OTS#2	1/12/10	1/25/10	10 d									
1164	1.6.2.4.2	Install Payload FM3	3/22/10	4/2/10	10 d									
1165	1.6.2.4.3	Observatory Flight 3 Performance Test	4/5/10	5/7/10	25 d									
1166	1.6.2.4.4	Pre-Environmental Review	4/16/10	4/16/10	0 d								△ 4/16	
1167	1.6.2.4.5	Observatory Flight 3 Environmental Test	5/10/10	7/9/10	45 d									
1168	1.6.2.4.6	Schedule Reserve	7/12/10	9/3/10	40 d									
1169	1.6.2.4.7	Turnover for Constellation Test	9/3/10	9/3/10	0 d								△ 9/3	
1170	1.6.3	Constellation Testing	8/3/09	12/10/10	355 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1171	1.6.3.1	Set-Up Constellation Test Facility	8/3/09	12/18/09	100 d	4	1	2	3	4	1	2	3	4
1172	1.6.3.2	Checkout With Single Observatory	3/22/10	4/30/10	30 d									
1173	1.6.3.3	Two-Observatory Test	7/5/10	8/13/10	30 d									
1174	1.6.3.4	Three-Observatory Test	9/6/10	10/15/10	30 d									
1175	1.6.3.5	Schedule Reserve	10/18/10	12/10/10	40 d									
1176	1.6.4	Final Integration (Pre-Launch)	12/13/10	5/4/11	103 d									
1177	1.6.4.1	Install Payload Attachment Fitting	12/13/10	12/15/10	3 d									
1178	1.6.4.2	Pre-Ship Functional Testing for Launch Campaign	12/16/10	2/23/11	50 d									
1179	1.6.4.3	Schedule Reserve	2/24/11	4/20/11	40 d									
1180	1.6.4.4	Pack, Ship & Delivery to Launch Site	4/21/11	5/4/11	10 d									
1181	1.6.4.4.1	Pre-Ship Review Preparations	4/21/11	4/27/11	5 d									
1182	1.6.4.4.2	Pre-Ship Review	4/27/11	4/27/11	0 d									
1183	1.6.4.4.3	Install in Shipping Container	4/28/11	4/29/11	2 d									
1184	1.6.4.4.4	Transport to Launch Site	5/2/11	5/4/11	3 d									
1185	1.6.4.4.5	Constellation Delivery to Launch Site	5/4/11	5/4/11	0 d									
1186	1.6.5	Launch Campaign	5/5/11	8/15/11	73 d									
1187	1.6.5.1	Constellation Launch Site Operations	5/5/11	7/6/11	45 d									
1188	1.6.5.2	Constellation / Launch Vehicle Operations	7/7/11	8/15/11	28 d									
1189	1.6.5.3	Launch	8/15/11	8/15/11	0 d									

MISSION OPERATIONS SYSTEM WBS 1.7

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1190	1.7	Mission Operations System	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
1191	1.7.1	Mission Ops Management	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
1192	1.7.1.1	Mission Ops Management	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
1193	1.7.1.2	Mission Operations Plan - Initial (PDR)	4/12/07	4/12/07	0 d					△ 4/12				
1194	1.7.1.3	Mission Operations Plan - Update (CDR)	3/13/08	3/13/08	0 d					△ 3/13				
1195	1.7.2	Mission Ops System Engineering	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
1196	1.7.3	GDS Supporting Elements (Non-MOS GDS efforts)	1/1/09	8/15/11	683 d									
1197	1.7.4	Operations (Pre-Launch)	8/15/08	8/15/11	782 d									
1198	1.7.4.1	Mission Ops Planning (Procs, Training, etc.)	8/15/08	8/15/11	782 d									
1199	1.7.4.2	Mission Operations Review	2/15/10	2/15/10	0 d							△ 2/15		
1200	1.7.4.3	Operations Readiness Review	2/15/11	2/15/11	0 d								△ 2/15	
1201	1.7.5	Missions Operations System V&V / Readiness Testing	2/15/10	8/15/11	391 d									

LAUNCH SYSTEM WBS 1.8

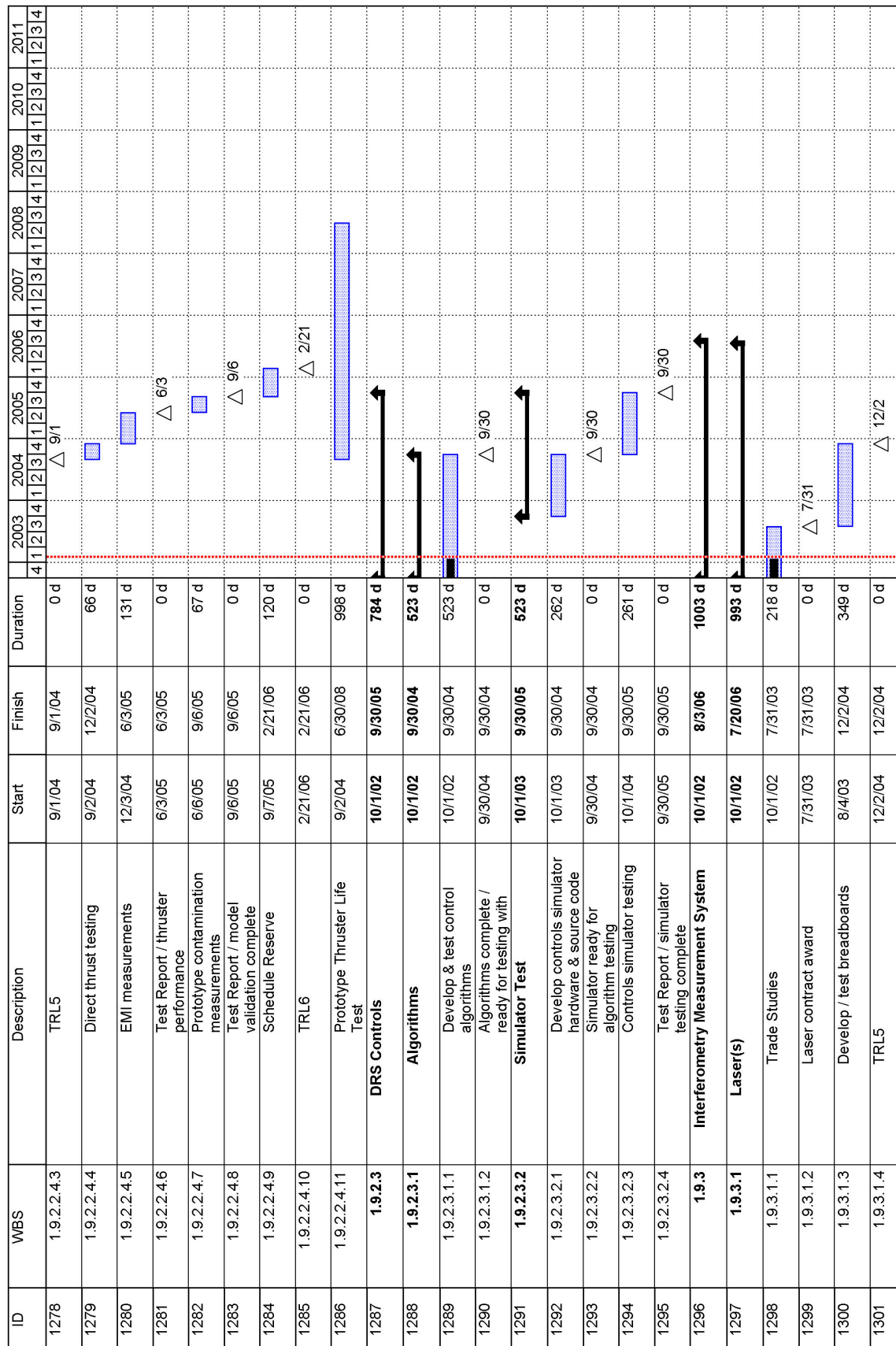
ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1202	1.8	Launch System	10/1/02	8/15/11	2315 d	4	1	2	3	4	1	2	3	4
1203	1.8.1	Spacecraft-To-Launch Vehicle Interface Definition, Verification & Coordination	10/1/02	8/15/11	2315 d									
1204	1.8.2	Launch Vehicle Build, Storage & Pre-Ship Ops	11/24/08	5/4/11	638 d									
1205	1.8.3	Launch Services (Launch Site Ops)	5/5/11	8/15/11	73 d									

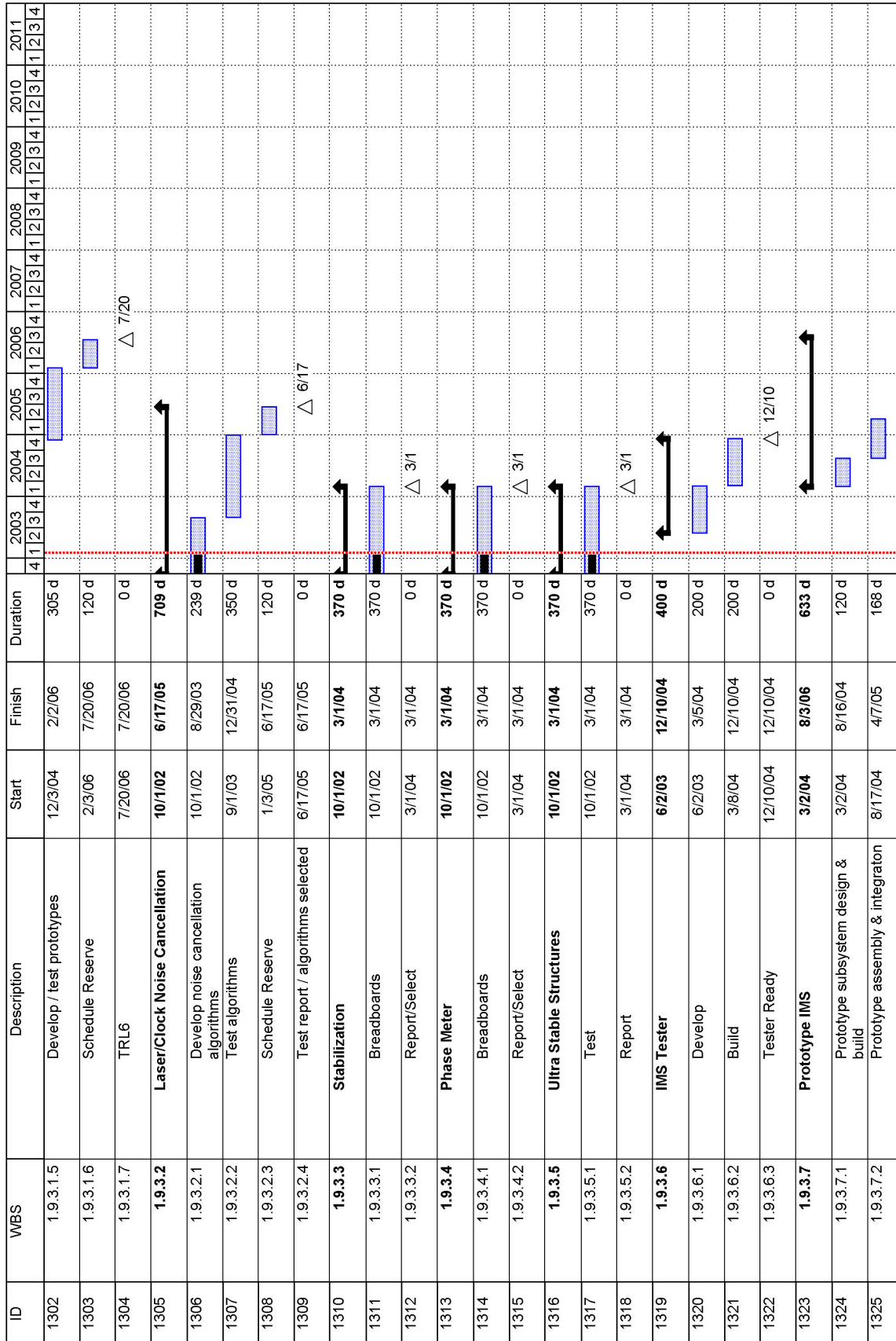
TECHNOLOGY WBS 1.9

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1206	1.9	Technology	10/1/02	6/30/08	1500 d	4	1	2	3	4	1	2	3	4
1207	1.9.1	Technology Management	4/25/03	11/15/06	927 d									
1208	1.9.1.1	Management	4/25/03	11/15/06	927 d									
1209	1.9.1.1.1	TRIP Board Findings	4/25/03	4/25/03	0 d									
1210	1.9.1.1.2	Annual Independent Review	6/30/04	6/30/04	0 d									
1211	1.9.1.1.3	Annual Independent Review	6/30/05	6/30/05	0 d									
1212	1.9.1.1.4	Technology Readiness Review	11/15/06	11/15/06	0 d									
1213	1.9.2	Disturbance Reduction System	10/1/02	6/30/08	1500 d									
1214	1.9.2.1	Gravitational Reference Sensor	10/1/02	11/3/06	1069 d									
1215	1.9.2.1.1	Housing Subsystem	10/1/02	4/12/04	400 d									
1216	1.9.2.1.1.1	Trade Studies	10/1/02	10/20/03	275 d									
1217	1.9.2.1.1.2	Targeted Studies	10/21/03	4/12/04	125 d									
1218	1.9.2.1.1.3	Report	4/12/04	4/12/04	0 d									
1219	1.9.2.1.2	Vacuum Subsystem	10/1/02	4/12/04	400 d									
1220	1.9.2.1.2.1	Trade Studies	10/1/02	10/20/03	275 d									
1221	1.9.2.1.2.2	Targeted Studies	10/21/03	4/12/04	125 d									
1222	1.9.2.1.2.3	Report	4/12/04	4/12/04	0 d									
1223	1.9.2.1.3	Caging Subsystem	10/1/02	4/12/04	400 d									
1224	1.9.2.1.3.1	Trade Studies	10/1/02	10/20/03	275 d									
1225	1.9.2.1.3.2	Targeted Studies	10/21/03	4/12/04	125 d									
1226	1.9.2.1.3.3	Report	4/12/04	4/12/04	0 d									
1227	1.9.2.1.4	Proof Mass Subsystem	10/1/02	4/12/04	400 d									
1228	1.9.2.1.4.1	Trade Studies	10/1/02	10/20/03	275 d									
1229	1.9.2.1.4.2	Targeted Studies	10/21/03	4/12/04	125 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1230	1.9.2.1.4.3	Report	4/12/04	4/12/04	0 d	4	1	2	3	4	1	2	3	4
1231	1.9.2.1.5	Proof Mass Control Subsystem	10/1/02	4/12/04	400 d	4	1	2	3	4	1	2	3	4
1232	1.9.2.1.5.1	Trade Studies	10/1/02	10/20/03	275 d									
1233	1.9.2.1.5.2	Targeted Studies	10/21/03	4/12/04	125 d									
1234	1.9.2.1.5.3	Report	4/12/04	4/12/04	0 d									
1235	1.9.2.1.6	Sensing & Forcing Subsystem	10/1/02	4/12/04	400 d	4	1	2	3	4	1	2	3	4
1236	1.9.2.1.6.1	Trade Studies	10/1/02	10/20/03	275 d									
1237	1.9.2.1.6.2	Targeted Studies	10/21/03	4/12/04	125 d									
1238	1.9.2.1.6.3	Report	4/12/04	4/12/04	0 d									
1239	1.9.2.1.7	Charge Control Subsystem	10/1/02	4/12/04	400 d	4	1	2	3	4	1	2	3	4
1240	1.9.2.1.7.1	Trade Studies	10/1/02	10/20/03	275 d									
1241	1.9.2.1.7.2	Targeted Studies	10/21/03	4/12/04	125 d									
1242	1.9.2.1.7.3	Report	4/12/04	4/12/04	0 d									
1243	1.9.2.1.8	I&T Mechanisms	10/1/02	4/12/04	400 d	4	1	2	3	4	1	2	3	4
1244	1.9.2.1.8.1	Trade Studies	10/1/02	10/20/03	275 d									
1245	1.9.2.1.8.2	Targeted Studies	10/21/03	4/12/04	125 d									
1246	1.9.2.1.8.3	Report	4/12/04	4/12/04	0 d									
1247	1.9.2.1.9	Prototype GRS (Lab Verified)	4/13/04	11/3/06	669 d									
1248	1.9.2.1.9.1	Prototype subsystem design & build	4/13/04	11/8/04	150 d									
1249	1.9.2.1.9.2	Prototype assembly & integration	11/9/04	6/30/05	168 d									
1250	1.9.2.1.9.3	TRL5	6/30/05	6/30/05	0 d									
1251	1.9.2.1.9.4	Perform GRS prototype testing	7/1/05	5/30/06	238 d									
1252	1.9.2.1.9.5	Test report / prototype complete	5/30/06	5/30/06	0 d									
1253	1.9.2.1.9.6	Schedule Reserve	5/31/06	11/3/06	113 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1254	1.9.2.1.9.7	TRL6	11/3/06	11/3/06	0 d	4	1	2	3	4	1	2	3	4
1255	1.9.2.2	Thrusters	10/1/02	6/30/08	1500 d									
1256	1.9.2.2.1	Emitter	10/1/02	9/1/04	502 d									
1257	1.9.2.2.1.1	Develop Emitter prototypes / initial testing	10/1/02	6/17/03	186 d									
1258	1.9.2.2.1.2	Prototype delivery (final configuration)	6/17/03	6/17/03	0 d									
1259	1.9.2.2.1.3	Prototype direct thrust testing	6/18/03	9/18/03	67 d									
1260	1.9.2.2.1.4	Test report / prototype ready for integration	9/18/03	9/18/03	0 d									
1261	1.9.2.2.1.5	Emitter prototype life testing	6/18/03	9/1/04	316 d									
1262	1.9.2.2.2	Neutralizer	10/1/02	2/27/04	369 d									
1263	1.9.2.2.2.1	Neutralizer trade studies	10/1/02	6/2/03	175 d									
1264	1.9.2.2.2.2	Neutralizer selection	6/2/03	6/2/03	0 d									
1265	1.9.2.2.2.3	Prototype build / test	6/3/03	8/4/03	45 d									
1266	1.9.2.2.2.4	Prototype delivery	8/4/03	8/4/03	0 d									
1267	1.9.2.2.2.5	Integrate Neutralizers with Emitter prototype	9/19/03	11/27/03	50 d									
1268	1.9.2.2.2.6	Direct thrust testing	11/28/03	2/27/04	66 d									
1269	1.9.2.2.2.7	Test report / prototype complete	2/27/04	2/27/04	0 d									
1270	1.9.2.2.3	Thruster Electronics	6/3/03	2/4/04	177 d									
1271	1.9.2.2.3.1	Develop Power Processing Unit (PPU) prototypes	6/3/03	12/3/03	132 d									
1272	1.9.2.2.3.2	PPUs ready for testing	12/3/03	12/3/03	0 d									
1273	1.9.2.2.3.3	PPU Testing	12/4/03	2/4/04	45 d									
1274	1.9.2.2.3.4	Test Report / PPUs ready Thruster prototype	2/4/04	2/4/04	0 d									
1275	1.9.2.2.4	Prototype Thruster	3/1/04	6/30/08	1131 d									
1276	1.9.2.2.4.1	Integrate & assembly prototype thruster emitters.	3/1/04	9/1/04	133 d									
1277	1.9.2.2.4.2	Prototype thrusters ready for testing	9/1/04	9/1/04	0 d									





ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1326	1.9.3.7.3	TRL5	4/7/05	4/7/05	0 d	4	1	2	3	4	1	2	3	4
1327	1.9.3.7.4	Perform IMS prototype testing	4/8/05	2/16/06	225 d									
1328	1.9.3.7.5	Test report / prototype complete	2/16/06	2/16/06	0 d									
1329	1.9.3.7.6	Schedule Reserve	2/17/06	8/3/06	120 d									
1330	1.9.3.7.7	TRL6	8/3/06	8/3/06	0 d									
1331	1.9.4	System Verification	10/1/02	4/30/07	1195 d									
1332	1.9.4.1	Integrated Modeling	10/1/02	4/30/07	1195 d									
1333	1.9.4.1.1	Modeling Environment	10/1/02	4/30/07	1195 d									
1334	1.9.4.1.1.1	Environment requirements definition / trade studies	10/1/02	5/15/03	163 d									
1335	1.9.4.1.1.2	LIME requirements / concept review	5/15/03	5/15/03	0 d									
1336	1.9.4.1.1.3	Develop Modeling Environment Release 1	5/16/03	11/17/03	132 d									
1337	1.9.4.1.1.4	Release 1	11/17/03	11/17/03	0 d									
1338	1.9.4.1.1.5	Develop Modeling Environment Release 2	11/18/03	8/31/05	467 d									
1339	1.9.4.1.1.6	Release 2	8/31/05	8/31/05	0 d									
1340	1.9.4.1.1.7	Develop Modeling Environment Release 3	9/1/05	4/30/07	433 d									
1341	1.9.4.1.1.8	Release 3	4/30/07	4/30/07	0 d									
1342	1.9.4.1.2	Quasi-Static Models	10/1/02	4/30/07	1195 d									
1343	1.9.4.1.2.1	Establish model baseline	10/1/02	11/17/03	295 d									
1344	1.9.4.1.2.2	Requirements validation complete	11/17/03	11/17/03	0 d									
1345	1.9.4.1.2.3	Trade Studies	11/18/03	8/31/05	467 d									
1346	1.9.4.1.2.4	Trade study report	8/31/05	8/31/05	0 d									
1347	1.9.4.1.2.5	Full model integration	9/1/05	4/30/07	433 d									
1348	1.9.4.1.2.6	Final trade study report	4/30/07	4/30/07	0 d									
1349	1.9.4.1.3	Dynamic Models	10/1/02	4/30/07	1195 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1350	1.9.4.1.3.1	Establish model baseline	10/1/02	11/17/03	295 d	4	1							
1351	1.9.4.1.3.2	Requirements validation complete	11/17/03	11/17/03	0 d									
1352	1.9.4.1.3.3	Trade Studies	11/18/03	8/31/05	467 d									
1353	1.9.4.1.3.4	Trade study report	8/31/05	8/31/05	0 d									
1354	1.9.4.1.3.5	Full model integration	9/1/05	4/30/07	433 d									
1355	1.9.4.1.3.6	Final trade study report	4/30/07	4/30/07	0 d									
1356	1.9.4.1.4	Phase Propagation Models	10/1/02	4/30/07	1195 d									
1357	1.9.4.1.4.1	Establish model baseline	10/1/02	11/17/03	295 d									
1358	1.9.4.1.4.2	Requirements validation complete	11/17/03	11/17/03	0 d									
1359	1.9.4.1.4.3	Trade Studies	11/18/03	8/31/05	467 d									
1360	1.9.4.1.4.4	Trade study report	8/31/05	8/31/05	0 d									
1361	1.9.4.1.4.5	Full model integration	9/1/05	4/30/07	433 d									
1362	1.9.4.1.4.6	Final trade study report	4/30/07	4/30/07	0 d									
1363	1.9.4.1.5	End-To-End Models	10/1/02	4/30/07	1195 d									
1364	1.9.4.1.5.1	Establish model baseline	10/1/02	11/17/03	295 d									
1365	1.9.4.1.5.2	Requirements validation complete	11/17/03	11/17/03	0 d									
1366	1.9.4.1.5.3	Trade Studies	11/18/03	8/31/05	467 d									
1367	1.9.4.1.5.4	Trade study report	8/31/05	8/31/05	0 d									
1368	1.9.4.1.5.5	Full model integration	9/1/05	4/30/07	433 d									
1369	1.9.4.1.5.6	Final trade study report	4/30/07	4/30/07	0 d									
1370	1.9.4.2	Test Bed Technology	10/1/02	6/30/06	979 d									
1371	1.9.4.2.1	Phase 1 - Approaches	10/1/02	9/30/05	784 d									
1372	1.9.4.2.1.1	Requirements & Trade Studies	10/1/02	9/30/05	784 d									
1373	1.9.4.2.1.2	Selection of Testbed Approaches	9/30/05	9/30/05	0 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1374	1.9.4.2.2	Phase 2 - Development	10/3/05	6/30/06	195 d	4	1	2	3	4	1	2	3	4
1375	1.9.4.2.2.1	Testbed(s) Development	10/3/05	6/30/06	195 d									
1376	1.9.4.2.2.2	Concept Demonstrations	6/30/06	6/30/06	0 d									

MISSION SOFTWARE WBS 1.10

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1377	1.10	Mission Software	12/15/03	7/2/10	1710 d	4	1	2	3	4	1	2	3	4
1378	1.10.1	Software Management	5/16/05	3/2/07	469 d									
1379	1.10.1.1	Software Management Plan - Initial (MDR)	5/16/05	5/16/05	0 d									
1380	1.10.1.2	Software Management Plan - Update (FSW PDR)	3/2/07	3/2/07	0 d									
1381	1.10.2	Software Requirements Document	5/26/06	3/2/07	200 d									
1382	1.10.2.1	SRD - Initial (FSW SSR)	5/26/06	5/26/06	0 d									
1383	1.10.2.2	SRD - Update (FSW PDR)	3/2/07	3/2/07	0 d									
1384	1.10.3	Software Test Plan	3/2/07	2/1/08	240 d									
1385	1.10.3.1	Software Test Plan - Initial (FSW PDR)	3/2/07	3/2/07	0 d									
1386	1.10.3.2	Software Test Plan - Update (FSW CDR)	2/1/08	2/1/08	0 d									
1387	1.10.4	Spacecraft Flight Software	12/15/03	6/19/09	1440 d									
1388	1.10.4.1	Requirements Definition & Analysis	12/15/03	5/26/06	640 d									
1389	1.10.4.2	Software Specification Review	5/26/06	5/26/06	0 d									
1390	1.10.4.3	Architectural Design	5/29/06	3/2/07	200 d									
1391	1.10.4.4	Preliminary Design Review	3/2/07	3/2/07	0 d									
1392	1.10.4.5	Detailed Design	3/5/07	2/1/08	240 d									
1393	1.10.4.6	Critical Design Review	2/1/08	2/1/08	0 d									
1394	1.10.4.7	Build 1 Development	2/4/08	7/18/08	120 d									
1395	1.10.4.8	Build 1 Release (C&DH FM1)	7/18/08	7/18/08	0 d									
1396	1.10.4.9	Build 2 Development	7/21/08	1/2/09	120 d									
1397	1.10.4.10	Build 2 Release (S/C FM1 I&T)	1/2/09	1/2/09	0 d									
1398	1.10.4.11	Build 3 Development	1/5/09	6/19/09	120 d									
1399	1.10.4.12	Build 3 Release (Observatory FM1 Performance Test)	6/19/09	6/19/09	0 d									
1400	1.10.5	Ground Data System (Mission Ops System)	1/1/08	7/2/10	654 d									

ID	WBS	Description	Start	Finish	Duration	2003	2004	2005	2006	2007	2008	2009	2010	2011
1401	1.10.5.1	Requirements / Preliminary Design	1/1/08	7/2/08	132 d	4	1							
1402	1.10.5.2	PDR	7/2/08	7/2/08	0 d									
1403	1.10.5.3	Detailed Design	7/3/08	12/31/08	130 d									
1404	1.10.5.4	CDR	12/31/08	12/31/08	0 d									
1405	1.10.5.5	MOS B1 Build & Test	1/1/09	7/2/09	131 d									
1406	1.10.5.6	Deliver MOS B1 (Observatory FM1 Performance Test)	7/2/09	7/2/09	0 d									
1407	1.10.5.7	MOS B2 Build & Test	7/3/09	7/2/10	261 d									
1408	1.10.5.8	Deliver MOS B2 (Constellation Testing)	7/2/10	7/2/10	0 d									
1409	1.10.6	Science Data System Software	1/1/08	7/2/10	654 d									
1410	1.10.6.1	Requirements / Preliminary Design	1/1/08	7/2/08	132 d									
1411	1.10.6.2	PDR	7/2/08	7/2/08	0 d									
1412	1.10.6.3	Detailed Design	7/3/08	12/31/08	130 d									
1413	1.10.6.4	CDR	12/31/08	12/31/08	0 d									
1414	1.10.6.5	SDS B1 Build & Test	1/1/09	7/2/09	131 d									
1415	1.10.6.6	Deliver SDS B1 (Observatory FM1 Performance Test)	7/2/09	7/2/09	0 d									
1416	1.10.6.7	SDS B2 Build & Test	7/3/09	7/2/10	261 d									
1417	1.10.6.8	Deliver SDS B2 (Constellation Testing)	7/2/10	7/2/10	0 d									
1418	1.10.7	IV&V	2/4/08	1/19/10	512 d									

H.3 Draft International Participation Plan

H.3.1 Summary

The formulation and implementation activities of the Laser Interferometer Space Antenna (LISA) project, part of the Structure and Evolution of the Universe (SEU) Program office, will require the transfer of hardware, software and technical data to support the relationships as presented in the International Contribution Summary Matrix. This matrix establishes the basis for the eventual development of the LISA Memorandum of Understanding between NASA and the European Space Agency (ESA).

It should be noted that the LISA Program is managed out of the Goddard Space Flight Center (GSFC) for NASA, and that the LISA Project is co-jointly managed by the GSFC and the Jet Propulsion Laboratories (JPL). This arrangement will entail careful coordination between the two centers in terms of the exportation and importation of hardware, software and technical data (please refer to Addendum E for further details).

For further information on the LISA project please refer to the LISA Program Plan, the LISA Project Plan, or the following LISA web sites:

- NASA <http://universe.gsfc.nasa.gov/>
- GSFC <http://lisa.gsfc.nasa.gov/>
- JPL <http://lisa.jpl.nasa.gov/>
- ESA <http://sci.esa.int/home/lisa/>

H.3.2 General Overview

H.3.2.1 International Traffic In Arms Regulations

As NASA is to plan and develop the LISA project in collaboration with ESA, the LISA development activities as well as all requirements to export hardware, software and technology will fall under the jurisdiction of the United States State Department. Most requirements to export

will fall under the State Department International Traffic in Arms Regulations (ITAR). As a general rule, any technical data regarding LISA that exceeds general purpose, marketing level information or information that has been previously placed into the public domain is subject to control under the ITAR. As a result, NASA needs to work under the authority of a Letter of Agreement (LOA) and eventually a Memorandum of Understanding (MOU) to support activities on LISA. The existence of this LOA and MOU will support the use of appropriate ITAR exemptions and support the acquisition of any State Department export licenses.

H.3.2.2 Letter of Agreement

NASA is currently operating under the framework of an LOA negotiated independently between NASA and ESA (Addendum A). The LOA between NASA and ESA became effective June 11, 2001. The agreement generally covers the formulation activities between NASA and ESA. As compared to the eventual MOU to be negotiated between NASA and ESA, the LOA is broad in scope and by its nature, absent of defined responsibilities of the individual parties. This tends to allow relatively *broad* discussions between NASA and the desired foreign party(s). LOAs generally do not go through the Circular 175 review process at the State Department before implementation.

H.3.2.3 Memorandum of Understanding

Eventually, NASA will be operating under the authority and framework of an MOU to be negotiated independently between NASA and ESA (Addendum B). The MOU will cover the implementation activities of the LISA program. Within the responsibilities section of the MOU, NASA will have to clearly and thoroughly define the actions to be performed by each party in order to conduct the LISA project, along with the benefits and rights accruing to each side. As the MOU will be used to provide authority for the eventual use of ITAR exemptions by NASA, as well as will serve as reference to industry Technical Assistance Agreement

(TAA) applications, complete and accurate definition of the responsibilities of the respective parties is critical. *Providing support (parts, assistance) to the foreign party outside the obligations as listed in the responsibilities portion of the agreement will require amendment to the original MOU or a separate agreement.*

H.3.3 Stages

H.3.3.1 Formulation

Discussions in the formulation stage tend to be broad, conceptual, generally absent of actual applied engineering and design information. The LOA(s) are broad in scope and by their nature, absent of defined responsibilities of the individual parties. This scenario generally affords NASA the ability to conduct, relatively *broad* discussions between NASA and the desired foreign party(s). As always, exchange of any NASA technical data must satisfy a “need to know” argument within the scope of the activity.

H.3.3.2 Implementation

By contrast to the formulation stage activities, exchange of technical information within the implementation stage must be more deliberate, supported by the responsibilities in the MOUs between NASA and the foreign partners and by available ITAR exemptions. Exchange of technical data will involve actual interface information and actual applied engineering information to be conducted in design reviews and technical interchange meetings. On occasion, there may be a need to partition technical meetings so that foreign parties are excluded from sessions of technical meetings where subject matter is to be discussed which exceeds what is necessary for the foreign party(s) to satisfy their responsibilities under the MOU. As always, NASA must ensure that the “need to know” argument is satisfied, within the responsibilities of the MOU.

H.3.4 LISA Industry Prime / Technical Assistance Agreements/ Non-Disclosure Agreements

H.3.4.1 Technical Assistance Agreements

GSFC anticipates that the selected prime integration contractor will choose to obtain a State Department approved TAA to support the providing of technical data and technical assistance to ESA and their eventual related entities within the LISA implementation phase. Any competing prime contractor will have to obtain a TAA to support its activities within the formulation phase. The TAA may also include all U.S. entities to be involved with the prime in directly participating in the LISA activities. In addition to possibly requesting signature on the TAA from ESA, the selected prime might also request that all foreign entities actively participating in the LISA program become signatory to the TAA. Active participation would generally mean participation in technical meetings, access to the U.S. prime contractor’s facilities and participation in any portion of program integration and testing efforts.

The completion of TAA(s) has proven to be a long lead-time item on other NASA programs, often causing delays in critical activities. Delays are caused by the requirements to amend existing TAA(s) to add domestic or foreign entities, as well as reluctance by the foreign partners to sign the TAA(s) in many cases. TAA preparation time should be factored into program schedules because TAA completion will critically affect the program.

H.3.4.2 Non-Disclosure Agreements

In addition to signing the U.S. prime contractor TAA, the U.S. State Department within the TAA approval process requires all parties whom are signatory to the prime TAA to sign a non-disclosure agreement.

All additional parties who obtain ITAR sensitive technical information directly from the selected U.S. prime, but are not actively involved in the program (i.e. not involved in integration and testing, participating actively in technical meetings) may be requested to

complete a non-disclosure agreement before the data will be exported to them.

H.3.5 Technology Transfer (Written Technical Data and Software)

H.3.5.1 Technical Data

As was stated previously, NASA generally can share ITAR controlled, technical data with the foreign partners (and related entities) by authority of the LOA and MOU, utilizing exemptions to the ITAR (22 CFR 126.4 / 22 CFR 125.4 (b)(3)). The technical data to be transferred must be supported by the requirements and responsibilities section in the LOA/MOU, and must not be specifically excluded by the Transfer of Technical Data and Goods section in the LOA/MOU.

H.3.5.2 NASA Provided Software

NASA provided software will generally be classified as technical data, when transferred to foreign partners and related entities. When embedded into ground support equipment or flight hardware, the software will be classified for export consistent with the modification of the higher hardware assembly. As most NASA software will be treated for export as if it were other technical (written) data, there is a requirement to mark the software to limit dissemination.

If NASA needs to transfer encrypted software and/or source code, these requirements are handled as special cases, as special provisions may be required to include special licensing.

H.3.5.3 Destination Control Statement

However, as NASA is forwarding technical data under specific exemption from licensing, the receiving foreign partner (and/or related entity(s)) need to know that subject data is to be protected, in accordance with the Transfer of Technical Data and Goods clauses of the LOA(s)/MOU(s). The clause that NASA needs to place (usually as a footer) on ITAR sensitive, technical data

provided to the NASA foreign partner is as follows:

These items are licensed by the United States for ultimate destination to (*European Space Agency*)(*insert which partner applies*). Diversion, retransfer, disclosure, or use contrary to applications specified in NASA agreement without prior U.S. authorization are prohibited.

If NASA does not mark the data as indicated above, the foreign partner cannot protect the data, and therefore is under no obligation to protect the NASA sensitive data. The U.S. industry competing primes have proven to be proficient at marking their data at all times.

H.3.5.4 Public Release of NASA Technical Data / Software

If there is a desire to release LISA ITAR sensitive technical data into a public forum, i.e. release through presentation and/or publication, the NASA STI process should be utilized. The originator of the requirement should follow the process contained in NPD 2220.5E/NPG 2200.2A, utilizing NASA form 1676.

Public release of NASA software could be completed utilizing the process associated with NPD 2210.1/NPG 2210.1, NASA form 1679.

H.3.6 LISA Customs/Transportation Issues (Hardware)

H.3.6.1 Temporary Exports of NASA Hardware

Under most conditions, ITAR controlled NASA hardware can be exported to a location outside of the United States without a “paper license” utilizing Government ITAR exemption 22 CFR 126.4. Generally, the following conditions **must** be satisfied: 1) The hardware must be exported to meet stated NASA responsibilities in the MOU, 2) the hardware is to remain under NASA ownership and 3) the hardware is to be returned to the United States within 4 years. U.S. industry must have a “paper license” through the State Department to temporarily export NASA items from the United States.

As NASA can export ITAR controlled hardware to a foreign partner without a license, it is highly desirable that NASA be established as the “exporter of record”. As obtaining an export license from the State Department can be a lengthy process and is not friendly to changes in shipping lists, destinations, values, etc., the Government exemption *affords* NASA the flexibility to modify shipping lists and shipment characteristics up to the time of shipment.

Provisions will need to be written into the individual NASA contracts with specific contract language that supports the notion that NASA and not the NASA contractors will export hardware to LISA foreign partners and related entities.

H.3.6.2 Permanent Exports of NASA Hardware

ITAR controlled NASA hardware can be exported to a location outside of the United States with an export license, a process initiated by utilizing State Dept. form DSP-5. Generally, the following conditions **must** be satisfied: 1) The hardware must be exported to meet stated NASA responsibilities in the MOU, 2) the hardware is to remain under NASA ownership and 3) the hardware is to remain outside of the United States for greater than 4 years.

Hardware that is to launch on a foreign launch vehicle will always require a State Department export license.

H.3.6.3 Return of NASA hardware from foreign partner facilities

As most of the hardware that will be exported to the LISA foreign collaborators is ITAR-controlled, it is critical that the foreign partner return of such hardware is coordinated through the project and the NASA GSFC Logistics Management Division.

NASA hardware is returned duty free from foreign partner and related entity locations outside of the United States.

NASA will pay freight charges and handling fees assessed in the United States for all NASA shipments to foreign locations. NASA will pay all freight charges and

handling fees to return all NASA hardware items from the foreign partners and related entities locations. The LISA MOU will contain a general obligation to facilitate free customs clearance (e.g. waiver of applicable duties or taxes) for entrances to, and exits from, each side’s respective country(s) for material required for LISA.

H.3.6.4 NASA Importation of ESA Hardware

According to Government ITAR exemption 22 CFR 126.4: “A license is not required for the temporary import, or temporary export, of any defense article, including technical data, by or for any agency of the U.S. Government (1) for official use by such an agency, or (2) for carrying out any foreign assistance, *cooperative project* or sales program authorized by law and subject to control by the President by other means. This exemption applies only when all aspects of a transaction are affected by a United States Government agency or when the export is covered by a United States Government Bill of Lading.

Therefore, ESA hardware, flight and non-flight, can be imported into the United States duty free utilizing the NASA Import Certification Process in accordance with 14 CFR Part 1217 (see <http://www.hq.nasa.gov/office/codei/nasaecp/ecpmain.html>.)

This process requires that a blanket, LISA NASA Import Certification be generated by Code *IS* in parallel with the development of the associated Memorandum of Understanding. When individual imports are anticipated, the LISA Program Manager must verify in writing that specifically identified articles to be entered on a particular date are the articles described in the LISA Importation. No additional paperwork requirements, i.e. Customs Form CF7501 should be required.

In addition to this requirement, the U.S. industry destination will most likely require that NASA generate a NASA GSFC 20-4 or equivalent DD1149 so that the ESA items can be provided as Government Furnished Equipment.

H.3.6.5 NASA Importation of LISA Items Procured Outside of the United States

Under the authority of ITAR 123.4 (a) NASA is allowed to: “temporary import (and subsequent export) without a license, for a period of up to four years, of unclassified U.S.-origin defense items (including any items manufactured abroad pursuant to U.S. Government approval) . . .”

Additionally, items procured outside of the United can be imported duty free into the United States utilizing the NASA Import Certification Process in accordance with 14 CFR Part 1217.

This process requires that an Importation Certification be prepared and endorsed by the NASA HQ or GSFC Procurement Officer. In addition, a Customs Form CF7501 (Entry Summary) will need to be generated by the GSFC Logistics Management Division, Transportation Branch.

H.3.6.6 Hand-carry of NASA Hardware from the United States

The hand-carry of NASA hardware to include NASA computers, from the United States needs to be planned and executed, as if it were to be transported via a commercial carrier to a foreign location. Severe fines and penalties can be levied **to the traveler** if improper procedures are used to hand-carry NASA hardware from the United States, particularly items that are controlled by the ITAR. Severe fines and penalties can also result if ITAR controlled items are improperly brought back into the United States as well.

Generally it is best if this activity is performed by a civil servant. Special provisions will need to be developed if a contract employee is to hand-carry an ITAR controlled NASA item from the United States, in support of the LISA mission.

H.3.7 Foreign Visitor Processing

H.3.7.1 Short-Term Visitors

The LISA Project will arrange for the necessary visitor documentation to support short term visits by members of ESA (and related entities), using license exemptions covered by the authority of the LISA LOA(s)/MOU(s). Foreign nationals under the employ of a US contractor will also be cleared using the following process; however, the US contractor is responsible for obtaining any State Department licensing or TAAs as authority to access GSFC.

All short-term visitors to GSFC who are not permanent US residents or US citizens must be approved through NASA’s Foreign National Management System (NFMMS). This process requires the completion of a Foreign Visitor Information Sheet. This profile sheet should only need to be completed once as a permanent record of one’s citizenship, passport number, and other pertinent information.

In addition, the NASA sponsor of the foreign national visit needs to fill out at least two additional forms for the Goddard Space Flight Center: Information Concerning Foreign National’s Visit to GSFC and Access For Foreign National to GSFC, which requires the GSFC sponsor to profile the particulars of the GSFC visit (i.e. location, sensitivity, names of visitors, if export sensitive, the legal authority for visit, etc.). In addition, the foreign nationals will require escorting by a GSFC sponsor, which requires (insert the name of the form).

These forms must be submitted by fax to the GSFC International Visits Coordinators Office (Code 100) for processing. Visits from countries of non-concern or non-proscribed countries typically require 10 business days to process. Visit requests from individuals from proscribed countries take a minimum of 30 days.

Visit requests are reviewed by the appropriate Security and Export Control activities at GSFC.

Visit requests may be forwarded to NASA HQ, such as requests from residents of proscribed countries.

H.3.7.2 Long-term Visitors (GSFC Badged Visitors)

The LISA Project will arrange for visitor documentation to support long-term visits by members of ESA (and related entities), using license exemptions covered by authority of the LISA LOAs/MOUs. Foreign nationals under the employ of a US contractor will also be cleared using the same process; however, the US contractor is responsible for obtaining any State Department licensing or TAAs as authority to support this access to GSFC.

LISA can arrange for long-term visitors to the GSFC who are not permanent US residents or US citizens to receive a GSFC picture badge after special approvals. Such approvals are currently under review. The long-term visitor must access GSFC on average three days a week to be eligible for a picture badge. As in the case of short-term access to GSFC, long-term, badged visitors must be approved through the NFNMS. Long-term, badged visitors may also be required to be approved through a National Agency Check (NAC) process or equivalent.

H.3.8 Facilities

H.3.8.1 Office Space

Tentatively, based upon the level of understanding reached in the MOU, office space can be made available based upon the availability of office space. It is assumed that office space would be required primarily for the period of Integration and Test (see Appendices C & D for milestones and expected dates).

H.3.8.2 Computer Access

According to NPG 2810.1, Chapter 4, Section 4.5.5 (with concurrence from Mr.

Henry Middleton, GSFC Information Technology (IT) Security Officer) the following information is currently the standard operating procedure in reference to computer access for Non-NASA employees/foreign visitors.

“Special Considerations for Non-NASA Employees or Contractors.” If a user is not a NASA employee or contractor, the following considerations apply for security investigations:

- Remote users other than NASA employees or contractors – a current Federal investigation performed by the user’s parent organization is acceptable if privileged access to a NASA computer system is required. If a remote user requires privileged or limited privilege access and has not been investigated by the user’s parent organization, the user’s NASA sponsor must request an investigation.
- International partners – international partners who seek access to U. S. Government IT resources, pursuant to an international agreement, must still be investigated. NASA Headquarters handles all investigations for representatives of foreign governments. Contact your CCS for more information.”

H.3.9 Configuration Management/ Documentation Management

Need to develop a process to control access to ITAR sensitive/otherwise sensitive controlled documents. This process should be delineated in the LISA Program/Project’s Configuration Management Plan(s) and referenced here.

Addendum H.3

Summary of ITAR Requirements for GSFC and JPL Guidance from GSFC's Export Control Office, Odell Young, GSFC Import/Export Specialist:

Exports shall be in compliance with applicable U.S. export laws and regulations and NASA's Export Control Program. A formal memorandum of understanding (MOU) or a letter of agreement (LOA) between NASA and the foreign parties detailing the specific roles and responsibilities of the parties will be required prior to exports.

The Department of State, administers the International Traffic in Arms Regulations (ITAR 22CFR 120-130) which governs the export of articles on the U.S. Munitions List (USML). Category XV of the USML controls spacecraft and associated equipment including related technical data and defense services as well as detailed design, development, manufacturing or production data for all spacecraft and specifically designed or modified components for all spacecraft systems.

Category XV Items under the LISA program will be exported in accordance with the below listed guidelines.

- LI. Permanent Exports: The export of hardware and technical data by NASA which will not be returned to the USA will require a U.S. Dept. of State Export License, DSP-5. If required for this Project, an estimated processing time of eight months will be included in the Project schedule.
- LI. License Exemptions: NASA is authorized to use ITAR licensing exemption 22CFR126.4(a)(2), for the temporary import, or temporary export, of defense articles or the performance of a defense service.

NASA may use ITAR licensing exemption 22CFR125.4(b)(3), for the export of technical data in furtherance of a contract requiring export of the data, and such data does not disclose the details of design, development, production, or manufacture of any defense article.

When applicable, ITAR exemptions to licensing requirements available to U.S. Government agencies will be used.

A determination must be made as to which licensing authority has responsibility for the effort under the proposal. The GSFC Export Control Office will assist Program representatives and NASA Headquarters Export Control Office in obtaining all necessary licensing. It is estimated that export license applications will be approved within six to eight months after submission.

All proposals or announcements of opportunity involving international participation should include clause 1852.225-70 Export Licenses.

Guidance from the JPL Office of Legislative and International Affairs, Stephanie Lear, Import/Export Administrator

Technical data – 125.4(b)(3) Exemption: Once an international agreement is in place, JPL may transfer interface technical data to NASA's foreign partner for use on a specific cooperative project.

Hardware – 126.4(a)(2) Exemption: JPL is not permitted to use the 126.4(a)(2) government exemption. Although, the NASA Management Office located at JPL may use this exemption to temporarily transfer ITAR controlled hardware to NASA's foreign partner without a license. Additionally, hardware exported using this exemption may not be hand carried by a JPL employee.

A State Department export license is required for all ITAR controlled hardware that will be permanently shipped out of the US. NASA will be the applicant for the license as it is their hardware.

H.4 Outline of Technical Responsibilities for International Participation

See LISA Partnership Pathfinder document following.



LASER INTERFEROMETER SPACE ANTENNA

Laser Interferometer Space Antenna (LISA)

PARTNERSHIP PATHFINDER

January 24, 2003

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1. INTRODUCTION

The Laser Interferometer Space Antenna (LISA) Mission represents a partnership between the European Space Agency (ESA) and the U.S. National Aeronautics and Space Administration (NASA) to develop a space mission capable of directly detecting gravitational waves as predicted by Einstein's General Theory of Relativity. To date this has never been accomplished although there is diverse indirect evidence of the existence of gravitational waves. The LISA mission will consist of three identical spacecraft orbiting about the Sun at one AU in a triangular formation providing a space-based laser interferometer to measure the very small dimensional changes that are caused by passing gravitational waves. These dimensional changes are on the order of one part in 10^{21} and, as such, their detection represents a profound technical challenge. The LISA Project is scientifically important in that it not only enables the direct study of strong gravitational interactions associated with black holes and probes Einstein's theory to new depths, but also provides a wholly new way of viewing the Universe outside the realm of electromagnetic radiation.

This document is developed entirely within the LISA Project to record the continuing definition of this NASA/ESA partnership to implement the LISA Mission. It will be periodically updated as the definition of the partnership evolves and it will serve to gather the technical content for the preparation of a future Memorandum of Understanding (MOU) between NASA and ESA Headquarters. This document is not intended to be an International Agreement and should not be construed as such. NASA and ESA Headquarters will subsequently negotiate a formal MOU prior to the Confirmation Review. It is, however, an agreement between the current NASA and ESA managers of the LISA Project as to their contemporary understanding of this partnership.

A Letter of Agreement is presently in effect that provides a framework for NASA and ESA to define the LISA Mission and the associated preparation of the subsequent MOU.

ESA and NASA will jointly cooperate in the development of the LISA Project with each partner seeking to contribute an approximately equal share. It is acknowledged that the technical complexity of the LISA Mission combined with the equal sharing of responsibilities will require a greater level of cooperation than has existed in earlier ESA/NASA cooperative space ventures. The LISA Mission will be implemented as a "sciencecraft," blurring the traditional distinction between the payload and the spacecraft and, consequently, technical insight must be widely shared to achieve and maintain a coherent design throughout development.

This initial version of the Partnership Pathfinder is intended to describe the key management responsibilities that constitute the LISA Project as they are presently understood and agreed upon by the current NASA and ESA managers of the LISA Project.

The LISA organizational approach is designed to capture the best talent in Europe and in the U.S. based on a NASA/ESA partnership that has naturally evolved from a decade-long collaboration between U.S. and European scientists dedicated to the definition of the LISA Mission. As a consequence of this collaboration, LISA represents a mature, well-studied mission concept as reflected in the Final Test Report published by ESA in April 2000. The scientists involved in the LISA Project are associated with many of the leading universities in the U.S. and in Europe. A number of these scientists are also intimately involved with the development of ground-based gravitational wave detectors both in the U.S. and Europe such that the valuable technical insight of these efforts represents a practical risk mitigation that is already available to the LISA Project.

Combining this scientific expertise with the maturity of the LISA mission concept and the considerable flight experience of JPL, GSFC, and ESTEC produces a combination of scientific and engineering talent, flight experience, and laboratory/test facilities that is ideally suited to proceed with the development of the LISA Project.

Although NASA and ESA are implementing the LISA Mission as partners, clear accountability is still an essential feature of a well-planned project. Our goal is to organize the partners in a way that the decision-making processes guarantee the appropriate influence of each partner and still maintain clear individual accountability. This is accomplished through the use of Integrated Technical Teams (ITTs) that are chaired by either NASA or ESA and traditional development offices that are led by either NASA in the U.S. or ESA in Europe. In this arrangement, technical decisions flow through the ITTs and programmatic decisions flow through the development offices. Technical decisions with programmatic impacts are coordinated within the ITTs.

In principle, the partner with the predominant role chairs the ITT. For example, in formulation ESA would chair the ITTs dealing with SMART-2 while NASA would chair the ITT dealing with formulation products. Where the partners have essentially equal involvement, they will negotiate a lead. This would include such formulation activities as the development of requirements, the definition and recommended allocation of mission elements, and the coordination of technology development. The individual ITTs report to the Integrated System Team. The Integrated System Team is a “team of teams” comprised of the senior system engineers from both NASA and ESA that represent all of the mission elements involved in the LISA Mission. It is chaired by NASA and ESA has the deputy-chair. The ITTs are quite active during formulation because they are heavily involved in definition. During this process, any deadlocks within an ITT or inconsistencies between ITTs are quickly reconciled by the Mission System Engineering Office. If the Mission System Engineering Office cannot decide, the matter is referred to the Project Manager for resolution. Once the details of the NASA and ESA work packages have been defined and agreed upon, they are assigned to NASA and ESA “offices” for implementation consistent with an Interface Control Document (ICD) developed and maintained by the ITT responsible for the original definition. During implementation the ITTs monitor the progress of development, evaluate potential changes, and maintain all of the ICDs. At this time, the bulk of the work gradually shifts away from the ITTs and into the developmental offices in order to get the flight hardware and software built and tested.

All of the related functions dealing with a particular area of development are grouped into “offices” and the lead for the day-to-day conduct of each office shall be assigned to either ESA or to a specific NASA field center that will be charged to implement the strategy and decisions previously agreed upon by ESA and NASA. The development offices provide the capability to accommodate the different business practices of NASA and ESA. The entity responsible for the day-to-day conduct of an office has the lead responsibility for implementing the functions of that office based on coordinated inputs from both ESA and NASA. The implementation decisions of these individual leads shall not adversely impact either the jointly agreed upon technical interfaces or their associated budgets and schedules without the prior, specific agreement of both NASA and ESA acting through the appropriate ITT. If the other partner has substantial involvement in a particular office, then the Deputy is represented by the other partner and, for the larger and more active offices, the Deputy is co-located. It is acknowledged that the overall technical complexity of the LISA Mission requires that these offices closely collaborate through the ITTs in the execution of their assigned functions.

The current LISA Project started with a Management Agreement between GSFC and JPL that was developed in October 2000 and dated November 1, 2000. The ESA input was based on a telephone conversation with ESTEC (John Credland) at about the same time. This Agreement focused primarily on implementation and, similarly, this first version of the Partnership Pathfinder also focuses on implementation although the organization for formulation is briefly presented.

2. PROJECT MANAGEMENT OFFICE

The Project Management Office is managed by both ESA and NASA and NASA has the overall mission management responsibility. Both Agencies are equally responsible for the overall mission success and for their respective financial resources as well as for the technical content, budgetary requirements, and the associated schedules to which the LISA Mission will be implemented. ESA and NASA collaborate to sub-allocate resources and establishing budgets, schedules, and technical requirements to all of the involved project elements.

LISA Project Manager: The LISA Project Manager is appointed by NASA and concurred upon by ESA. He/she is responsible for the overall management of the LISA Project. This responsibility is implemented through two Deputy Project Managers, one responsible for activities funded by ESA or its member states and the other responsible for activities funded by NASA.

ESA Deputy Project Manager: The ESA Deputy Project Manager is specifically responsible for all LISA-related activities funded by ESA or its member states, participates fully in the daily decision-making of the Project Management Office, and represents the LISA Project Manager whenever necessary.

NASA Deputy Project Manager: The NASA Deputy Project Manager is specifically responsible for all LISA-related activities funded by NASA, participates fully in the daily decision-making of the Project Management Office, and represents the LISA Project Manager whenever necessary.

ESA and NASA Project Scientists: The ESA and NASA Project Scientists are jointly responsible for ensuring that the LISA Project meets the scientific requirements established by the Mission Scientists and the LISA International Science Team. The ESA and the NASA Project Scientists work together in reviewing projected LISA technical performance in relation to the base lined scientific requirements, in ensuring that project activities remain consistent with meeting these scientific requirements, and in providing day-to-day scientific guidance to the LISA Project. The Project Scientists are responsible to fully coordinate with their respective Mission Scientists to ensure that project activities remain consistent with meeting science requirements.

3. MISSION SCIENCE OFFICE AND THE LISA INTERNATIONAL SCIENCE TEAM

The Mission Science Office is jointly managed by the NASA Mission Scientist and the ESA Mission Scientist. Together, they lead the LISA scientific activities and are responsible for establishing and quantifying the LISA scientific requirements with the support of the LISA International Science Team.

ESA and NASA Mission Scientists: The ESA and NASA Mission Scientists are responsible for the definition of the LISA scientific requirements. They perform this task in close coordination with the LISA International Science Team, of which they serve as co-chairs. They are responsible for the effective coordination of all of the U.S. and European scientific activities related to the LISA Mission. The Mission Scientists are also responsible for developing the plans for the LISA science analysis, for science outreach, and for managing and funding the LISA International Science Team. They jointly monitor the LISA designs and performance capabilities in relationship to the scientific requirements.

4. MISSION SYSTEM ENGINEERING OFFICE

The Mission System Engineering Office is managed by both ESA and NASA and NASA has the lead for the day-to-day activity. This Office is responsible for ensuring system-level coherence of all design and developmental activities of all of the mission elements. It also leads the Integrated System Team as a “team of teams” with all major project elements represented.

NASA System Engineering Manager: The NASA System Engineering Manager is responsible for the following tasks:

- Chair of the NASA/ESA Integrated System Team;
- Jointly manage the overall design of the LISA Mission consistent with the LISA Mission Requirements Document and the Integration and Verification Plans;
- Jointly manage the definition of the Mission Requirements Document and the Integration and Verification Plans;
- Jointly manage the technical coordination of all individual project elements in order to achieve overall system-level coherence;
- Jointly manage the definition and implementation of interfaces between the various system elements, and
- Jointly manage the coherence of the system budgets within the available resources.

ESA Deputy System Engineering Manager: The ESA Deputy System Engineering Manager is responsible for the following tasks:

- Deputy-Chair of the NASA/ESA Integrated System Team;
- Jointly manage the overall design of the LISA Mission consistent with the LISA Mission Requirements Document and the Integration and Verification Plans;
- Jointly manage the definition of the Mission Requirements Document and the Integration and Verification Plans;
- Jointly manage the technical coordination of all individual project elements in order to achieve overall system-level coherence;

- Jointly manage the definition and implementation of interfaces between the various system elements, and
- Jointly manage the coherence of the system budgets within the available resources.

Integrated Technical Teams: The LISA Project uses ITTs throughout definition and development in order to effectively accommodate the interests of both partners and to achieve a sustained focus on the mission elements to be developed. This approach also minimizes the impact of the cultural differences between NASA and ESA in that it represents a management approach already familiar to both NASA and ESA. Moreover, when combined with the long-term commitments of senior scientists and engineers, this approach provides the flexibility to smoothly and efficiently transition from formulation into implementation simply by restructuring the membership of the existing ITTs. All of the ITTs coordinate their activities through the Integrated System Team and both the ITTs and the Integrated System Team report to the Mission System Engineering Office.

Integrated System Team: The most intense collaboration between partners occurs in the requirements and design definition. This occurs within the Integrated System Team that is composed of the system engineers and scientists from the involved ITTs and is chaired by the Mission System Engineering Managers from NASA and ESA. To initialize and accelerate the exchange of information between the scientists and the newly assigned engineers, the Mission System Engineering Office sponsors at least three Science / Engineering Workshops per year. Once the designs are defined to the level of specifications, they are then assigned to NASA or ESA offices for development. It is estimated that over 75% of both partner contributions will be spent on traditional contracts managed individually by the partners working to well-defined ICDs. Once development is completed, integration begins in Europe and is completed in the U.S.

The ITTs are most active during formulation because they are heavily involved in definition. Once the details of the NASA and ESA work packages have been defined and agreed upon, they are assigned to NASA and ESA offices for development to an ICD developed and maintained by the ITT responsible for the original definition. During implementation the emphasis shifts to monitoring the progress of development, evaluating potential changes, and maintaining the previously established ICDs. In implementation the bulk of the work gradually shifts away from the ITTs and into the development offices where the flight hardware and software is built and tested.

SE&I Contractor: The LISA Project will utilize a System Engineering & Integration (SE&I) Contractor to support the Integrated System Team, conduct trade-off studies, support the definition and maintenance of the ICDs for the ITTs, and ultimately implement the integration responsibilities assigned to NASA and to support the integration activities assigned to ESA. The SE&I contractor is intimately involved in assessing proposed changes to the ICDs as preparation for the subsequent I&T. The SE&I contractor supports all of the ITTs and represents the “eyes and ears” of the Mission System Engineering Office in identifying sensitive and complex issues that are not likely to be resolved within a given ITT. In such cases, the contractor proactively facilitates a solution to keep the definition process moving smoothly. The contractor will be initially available early in 2005 to support the definition process.

5. ORGANIZATIONAL DETAILS

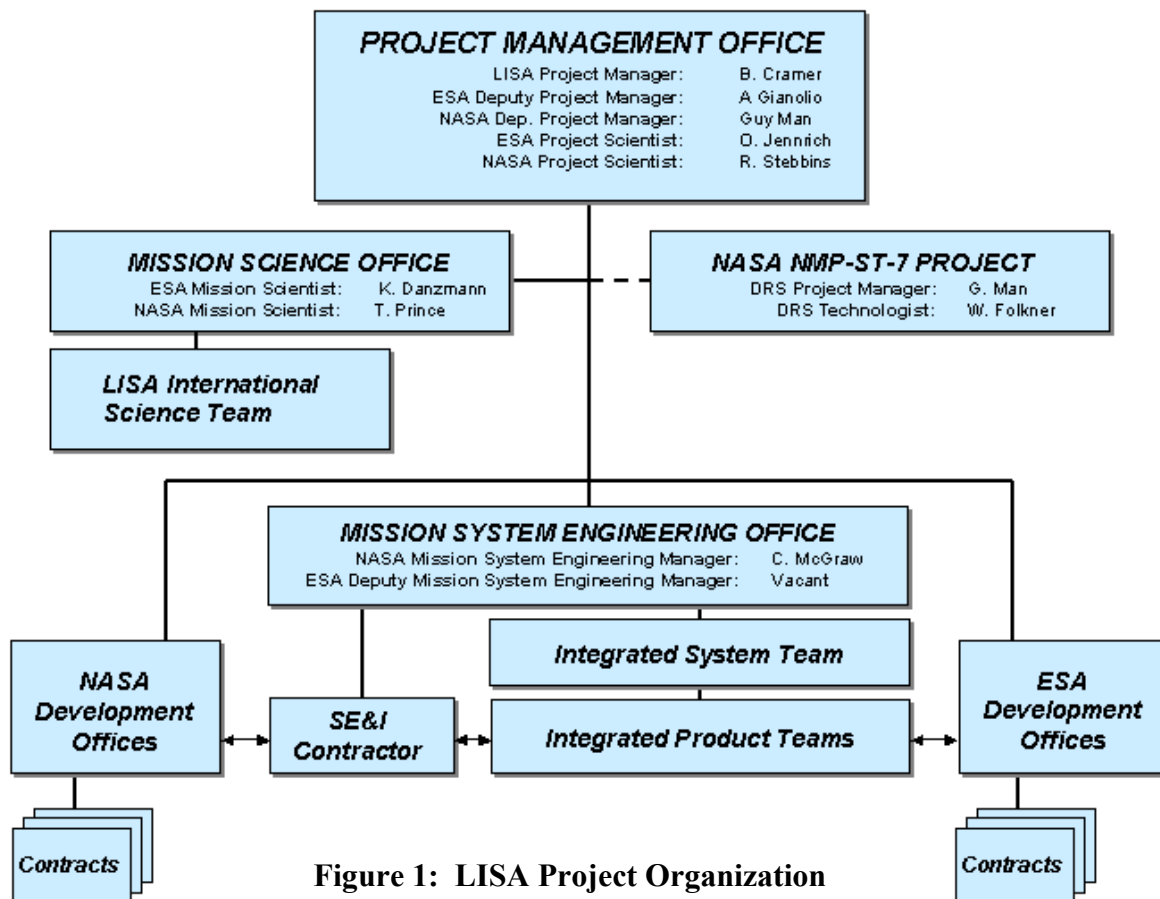


Figure 1: LISA Project Organization

Figure 1 depicts the LISA Project organization. The same basic organizational structure serves technology development, formulation, and implementation. This is accomplished by a gradual restructuring of the ITTs to optimally serve the current needs of the Project. Similarly, the NASA and ESA development offices also evolve with the ITTs with which they are closely associated. This organizational approach also enables a smooth and efficient transition from between phases by systematically evolving the structure of the ITTs to optimally meet the anticipated needs of the next phase.

A typical organizational structure of the ITTs and their corresponding development offices for formulation is reflected in Figure 2. The first five ITTs presently support technology development and the last two ITTs support formulation and are still in planning.

NASA DEVELOPMENT OFFICES	INTEGRATED TECHNICAL TEAMS (ITT)	ESA DEVELOPMENT OFFICES
Requirements Support	Requirements Definition/ Mission Design	Requirements Support
Mission Element Definition Support	Mission Element Definition / Allocation	Mission Element Definition Support
NASA Technology Development	Technology Coordination	ESA Technology Development
SMART-2 Support	SMART-2 Coordination	SMART-2 Development
GRS Test Package Development (ST-7/DRS)	SMART-2 Test Package Definition	GRS Test Package Development (LTP)
Operations Concept Development	Operations Concept Definition	Operations Concept Development
Formulation Product Development	Formulation Product Definition/ Coordination	Formulation Product Development

Figure 2: LISA Formulation Organization

The allocation of mission elements between NASA and ESA is about 90% complete. Several areas are still in negotiation and will be resolved later in FY03. The current status of this process is shown in Figure 3. These data are updated with each succeeding version of the Partnership Pathfinder to reflect the latest agreements relative to the allocation process. It is necessary to complete this activity as soon as possible so as to enable ESA to commence the process of soliciting European member state contributions for the payload.

NASA		European	
GSFC	JPL	ESA	ESA MEMBER STATES
Mission Management NASA Business Management Technology Development System Engineering Integrated Modeling Payload Software Observatory Integration Final End-to-End Testing Launch Campaign Launch Vehicle On-Orbit Check-Out	Payload Management Technology Development ST-7 / DRS Science Office Operations Payload Components: <ul style="list-style-type: none"> – Test Mass – GRS Electrode Housing – Phase Meter – Actuator – Structure – Optical Benches – Interferometer Optics – Simulators – Ground Support Equipment Payload Integration	European Business Mgmt Spacecraft Management <ul style="list-style-type: none"> – Three Spacecraft – Three Propulsion Modules – Ground Support Equipment – Simulators Manage Member State Contributions Technology Development System Engineering SMART-2 Mission	LTP Payload Components: <ul style="list-style-type: none"> – GRS Front-End Electronics – Charging System – GRS Vacuum & Structure – GRS Software – Beam Acquisition Sensor – Laser Stabilization Bench – Lasers – Telescopes – Ground Support Equipment Initial Payload Integration Science Support

Figure 3: LISA Mission Element Responsibilities

Given the responsibilities for mission elements shown in Figure 3, a typical organizational structure of the ITTs and their corresponding development offices for implementation is depicted in Figure 4. The evolution to this organization begins late in formulation and is in place at the beginning of implementation.

NASA DEVELOPMENT OFFICES	INTEGRATED TECHNICAL TEAMS (ITT)	ESA DEVELOPMENT OFFICES
System Specification Support	System Specification Maintenance	System Specification Support
Standards Development/Modification	Standards Coordination	Standards Development/Modification
Flight S/W and GN S/W Development	Flight & Ground S/W Definition Flight S/W and GN S/W ICDs	Flight S/W Development
System/Subsystem Verification	System Verification Definition	System/Subsystem Verification
Payload Component Development	Payload Definition Payload ICDs	Payload Component Development
Spacecraft Support	Spacecraft Definition Spacecraft ICDs	Spacecraft Development (Including Prop Modules)
Overall Payload Integration Observatory Integration/Final Testing	I&T Definition I&T ICDs	Early Payload Integration Early Observatory Integration

NASA DEVELOPMENT OFFICES	INTEGRATED TECHNICAL TEAMS (ITT)	ESA DEVELOPMENT OFFICES
Launch Vehicle Development	Launch Vehicle Launch Vehicle ICDs	Launch Vehicle Support
Operations Capability Development	Operations Definition Operations ICDs	Operations Support
Science Data Analysis Capability Development	Science Data Analysis Definition	Science Data Analysis Support

Figure 4: LISA Implementation Organization

6. MISSION TECHNOLOGY ACTIVITIES

ESA and NASA will establish and maintain independent but coordinated technology development efforts. NASA will establish and maintain a Technology Office managed by the NASA Mission Technologist. The NASA Mission Technologist is responsible for planning and managing the development of the advanced technologies in the US that represent the technical basis of the LISA Project.

The LISA Project Office at ESTEC, in close coordination with the relevant ESA support organizations, is responsible for planning and coordinating the development of the advanced technologies that represent the technical basis of the LISA Project in Europe. The ESA Architect is responsible for the coordination and management of the LISA Technology activities in close cooperation with the appointed Technical Officers, who are responsible for leading the individual activities. The ESA Architect and the NASA Mission Technologist are responsible for coordinating and reporting the results of their respective technology efforts through the ITT responsible for Technology Coordination.

7. LISA TECHNOLOGY FLIGHT VALIDATION

ESA and NASA agree that the early flight validation of the GRS technologies is important in enhancing our confidence of achieving the LISA Mission. To this end, both Agencies have indicated their intention to fly their respective test packages (LISA Test Package (LTP) and Disturbance Reduction System (DRS)) on a precursor mission. ESA will fly the LTP on the technology validation mission known as SMART-2. ESA has also offered NASA the opportunity to fly their DRS on the same mission and that offer has been accepted in principle. A subsequent, separate Memorandum of Understanding between ESA and NASA will formalize this cooperation.

8. CO-LOCATION OF RESIDENT REPRESENTATIVES

For each of the key positions described above, each Agency shall guarantee the availability of office accommodations and support services to representatives of the other Agency as described herein to discharge their functions and to facilitate the exchange of necessary information and data. The host Agency shall make all arrangements for access to those premises, arrange participation in any related meetings, and provide the associated documentation as required to successfully implement the functions of the key positions described herein.

9. SIGNATURES

Bryant Cramer,
LISA Project Manager

Alberto Gianolio,
Deputy Project Manager (ESA)

Guy Man,
Deputy Project Manager (NASA)

H.5 List of Abbreviations and Acronyms

A&D	Architecture & Design
ACS	Attitude Control Subsystem
AM	Amplitude Modulated
ARCS	Austrian Research Centers Seibersdorf
ATD	Advanced Technology Development
AU	Astronomical Unit (150 Million km)
B1	Build 1
B2	Build 2
B3	Build 3
bps	bits per second
C&DH	Command and Data Handling
CA	Confirmation Assessment
CCD	Charge Coupled Device
CCP	Contamination Control Plan
CDM	Cold Dark Matter
CDR	Critical Design Review
CFR	Code of Federal Regulations
CHAMP	CHALLENGING Minisatellite Payload
CPS	Central Processing System
DOORS	Dynamic Object Oriented Requirements System
DR&D	Disposal, Re-Entry and Decommissioning
DRS	Disturbance Reduction System
DSN	Deep Space Network
E/O	Electro-Optic
E&PO	Education and Public Outreach
ELV	Expendable Launch Vehicle
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic interference
EO-1	Earth Observing-1
EOM	Electro-Optic Modulator
ESA	European Space Agency
ESTEC	European Space Research and Technology Center
FAD	Formulation Authorization Document

FEEP	Field Emission Electric Propulsion
FM	Frequency Modulated (in Section D)
FM	Flight Model (in Section G)
FRR	Flight Readiness Review
FSW	Flight Software
FTR	Final Technical Report
GaAs	Gallium Arsenide
GDS	Ground Data System
GHz	gigahertz
GPS	Global Positioning System
GRACE	Gravity Recovery and Climate Experiment
GRC	NASA Glenn Research Center
GRS	Gravitational Reference Sensor
GSFC	NASA Goddard Space Flight Center
GW	Gravitational Wave
HGA	High Gain Antenna
HW	Hardware
I&T	Integration and Test
ICD	Interface Control Drawings / Documents
ICR	Initial Confirmation Review
IMS	Interferometry Measurement System
ISO	International Standards Organization
IT	Information Technology
ITAR	International Traffic in Arms Regulations
ITT	Invitation To Tender
IV&V	Independent Verification and Validation
JILA	Joint Institute for Laboratory Astrophysics
JPL	NASA Jet Propulsion Laboratory
JWST	James Webb Space Telescope
LGA	Low Gain Antenna
LIGO	Laser Interferometer Gravitational Wave Observatory
Li-Ion	Lithium Ion
LISA	Laser Interferometer Space Antenna
LIST	LISA International Science Team
LOA	Letter of Agreement
LRD	Launch Readiness Date

LRR	Launch Readiness Review
LSR	LISA Science Requirement
LTP	LISA Test Package
LZH	Laser Zentrum Hannover
MAG	Mission Assurance Guidelines
MAR	Mission Assurance Requirements
MBH	Massive Black Holes
MBW	Measurement Bandwidth, 0.1 mHz – 0.1 Hz
MC	Mission Concept
MCR	Mission Concept Review
MDR	Mission Definition Review
MHz	megahertz
mHz	millihertz
MICM	Multi-variable Instrument Cost Model
MM	Minimal Mission
MOC	Mission Operations Center
MOPA	Master Oscillator with Power Amplifier
MOR	Mission Operations Review
MOU	Memorandum of Understanding
MPPT	Maximum Power Point Tracking
MRR	Mission Readiness Review
MSC	Mission Success Criteria
M_{\odot}	Solar Mass (2×10^{30} kg)
NAC	National Agency Check
NAR	Non-Advocate Review
NASA	National Aeronautics and Space Administration
Nd-YAG	Neodymium Yttrium Aluminum Garnet
NEPA	National Environmental Policy Act
NFNMS	NASA Foreign National Management System
NIST	National Institute for Standards and Technology
NMP	New Millennium Program
nm	Nanometer (10^{-9} meters)
NPD	NASA Policy Directive
NPG	NASA Procedure and Guideline
NPRO	Non-planar Ring Oscillator
OA	Optical Assembly

OAT	Observatory Architecture Team
ORR	Operational Readiness Review
PDR	Preliminary Design Review
P/L	Payload
PCA	Program Commitment Agreement
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PLL	Phase-Locked-Loop
PM	Proof Mass
pm	picometer (10^{-12} meters)
PSR	Pre-Shipment Review
R1	Release 1
R2	Release 2
R3	Release 3
RCS	Reaction Control System
RF	Radio Frequency
RFI	Request For Information
rms	root mean square
s	seconds
S/C	Spacecraft
SBIR	Small Business Innovation Research
SCR	System Concept Review
SDMP	Science Data Management Plan
SDP	Safety Data Package
SDS	Science Data System
SE	Systems Engineering
SE&I	System Engineering and Integration
SEMP	System Engineering Management Plan
SEU	Structure and Evolution of the Universe
SIM	Space Interferometry Mission
SM2	SMART-2
SMA	Safety and Mission Assurance
SMART-2	Small Missions for Advanced Research in Technology
SMP	Science Management Plan
SMP	Software Management Plan
SNR	Signal-to-Noise Ratio

SRR	System Requirements Review
SSP	System Safety Plan
ST-7	Space Technology-7
ST&E	Science, Technical and Economics
STAR	Space Triaxial Accelerometer for Research applications
STP	Software Test Plan
STOP	Integrated Structural, Thermal, and Optical analysis
SuperSTAR	Super Space Triaxial Accelerometer for Research applications
SW	Software
T&C	Technology & Commercialization
TAA	Technical Assistance Agreement
TAMA	Japanese ground based gravitational wave detector project
TDI	Time Delay Interferometry
TES	Tropospheric Emission Spectrometer instrument
TRIP	Technology Readiness and Implementation Plan
TRL	Technology Readiness Level
TRR	Technology Readiness Review
TV	Thermal Vacuum
ULE	Ultra-Low Expansion
USO	Ultra-Stable Oscillator
UV	Ultraviolet
W	Watts
WBS	Work Breakdown Structure
WD	White Dwarf

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